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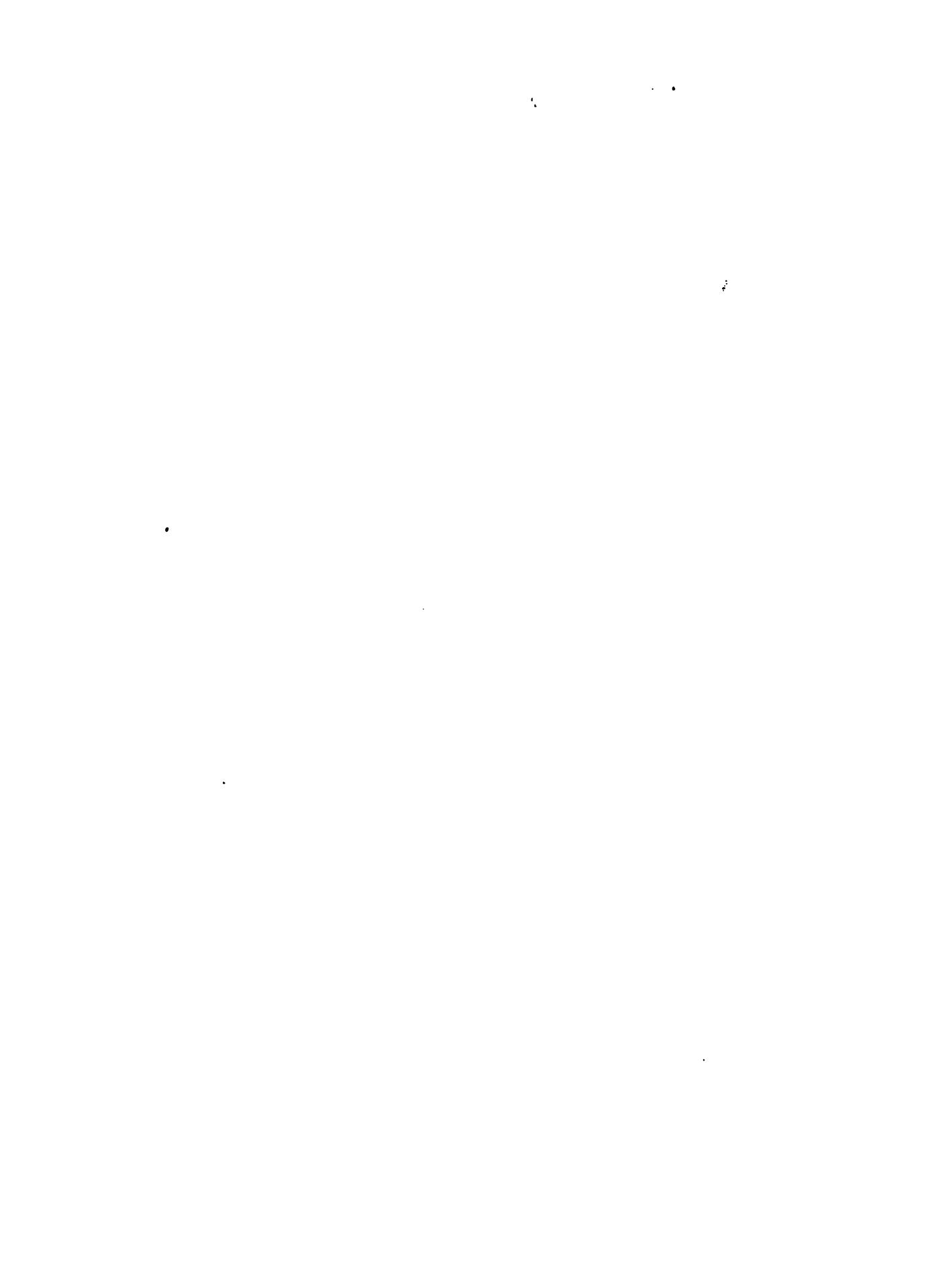
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Geological Survey, VOL II Pt

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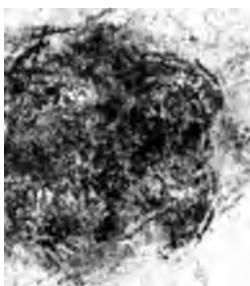






RECORDS
OF THE
GEOLOGICAL SURVEY OF INDIA.
VOL. II, Part 1.

1869.



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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 1.]

1869.

[February.

THE VALLEY OF THE POORNA RIVER, WEST BERAR; *by A. B. WYNNE, ESQ., F. G. S., &c.*

The Poorna valley between longitudes 76° and 78° east, is traversed by the 21st parallel of north latitude. It is about 124 miles in length from its upper or eastern end to where it passes into the larger valley of the Taptee; the main directions of both diverging at first so as to include an angle of about 50° but afterwards becoming more nearly parallel or east and west. The width of the valley may be roughly estimated at from 30 to 40 miles on an average, but is in places greater.

Its boundaries are—on the south, the range of the Adjunta ghâts,—an abrupt scarp of the Deccan plateau produced, and gradually becoming less marked, to the eastward—some hilly and undulating ground forming the watershed in that direction between the Poorna and Wurdah valleys; and on the north, the lofty bold and varied escarpments of the Gwilghur range, which carry a high crest westwards near to where the Poorna river runs into the Taptee, the termination of the mountain range here sinking with some rapidity, though not being by any means abrupt.

The southern ranges pass imperceptibly into the usual steppe character of the Deccan, while the mountains on the north are a complex mass or group with a generally east and west extension, and such summit elevations as 3,595, 3,778, and 3,975 feet, declining gradually northward into the valley of the (upper) Taptee.*

These Gwilghur mountains are intersected by steep glens and wider valleys, sometimes presenting nearly vertical precipices of great but unmeasured height which may in places reach 1,000 to 1,200 feet. The glens and ravines wind intricately among the mountains, affording some very fine scenery, and as their streams seldom retain water for any considerable time, the wildness of this is increased by solitude.

The valley of the Poorna possesses but little variety of geological interest and is principally distinguished by monotonous repetitions of features observable in crossing the Deccan from the seaward to this locality, where each hill and ghât and undulating slope or plain exhibits similar kinds of nearly horizontal flows of gray amygdaloidal trap, with here and there a bed of harder texture of columnar structure, or of bright red bole, or alternations of these; the traps sometimes containing numerous zeolites.

In the river valleys, and where superficial 'rain-wash' has accumulated, a light brown 'kunkury' alluvium is associated with calcareous sub-recent conglomerate below and black cotton soil above, one being quite as occasional and accidental as the other, the conglomerate or concrete being perhaps the most persistent along the river courses, the brown alluvium or (?) "soda soil"† more universal and the cotton soil occurring, subject only to the rule that it is always uppermost.

Upon descending the escarpment of the Deccan into the valley of the Poorna its alluvial plain is entered, often at no great distance from the ghât, and stretching away as far as can be seen; only clear days permitting some of the nearest mountains upon the opposite side

* These heights are taken from a small photograph copy of a map of Gangra by J. Mulheran, Esq.

† This efflorescing brown alluvium is considered by Mr. Balfour different from the "soda soil" of Madras.

become visible. Heights not being given upon the best maps obtainable, the elevation of the plain and its boundary ranges could not be ascertained even approximately in the absence of a barometer—which is to be regretted, as the main watershed of India separates the sources of the Poorna from those of the Wurdah, the water of the former being discharged eventually at Surat whilst those of the Wurdah are tributary to the Godaveri, which enters the sea below Rajahmundry on the opposite side of the peninsula.

The alluvium of this great plain, although of very considerable depth and occupying so large an area, is as completely isolated from that of the neighbouring rivers as such a deposit can be said to be. A section crossing the valley from the Adjunta ghâts, by Edulabad across the Poorna river, to the western termination of the Gawilghur range, would show the ordinary trap of the Deccan, forming the high ground at either end, and an undulating country between, which viewed from above or from a distance has a plain-like aspect, but frequently exposes the rocks of which it is formed; consisting of the usual traps, here and there covered only by slight detrital accumulations of the same kinds as those of the Deccan. Except on the very banks of the Poorna no considerable quantity of alluvial matter would be found, and this does not extend far from the river at either side. North and south through Mulkapoort a different section would be obtained. Here a wide space, chiefly on the south side of the Poorna, is occupied by fine brown calcareous alluvium with 'kunkur' and is connected by a narrow neck, at Peeprala, with the great alluvial deposit of this valley which in thickness may exceed 150 feet; and nothing else, save varieties of this, is to be seen in or near the river from Dadulgaon on its south bank eastwards up the stream nearly to the "sungum" or junction of the Phairlee river, which enters the Poorna near Kowsa, if we except two or three small exposures of trap in its bed near Peeprala Pulsoad and about three miles west of Burra Golagaon. The Poorna changes its course from the N. N. E. at the junction of the above-named tributary, and thence takes a westerly direction:—the alluvium on its south side seldom extending beyond an average of ten miles from the river and nearly coinciding along its southern boundary with the Nagpoor extension of the Great Indian Peninsula Railway—while on the north it reaches nearly to the base of the mountains. On the east its rather arbitrary and more or less indefinite boundary closely approaches the watershed east of Ellichpoor and bending southward traverses undulating country eventually reaching the flanks of the hills near Oom rawuttee.*

All round the margin of this alluvial tract is a belt of country that might or might not with propriety be included within it, although the surface deposits there do not conceal the underlying rock, the exposure of which was taken as the chief guide in determining the line of boundary. On the north and east, this tract of country is very stony, though nothing resembling an old beach is seen, and it may be supposed that streams descending from the mountains and hills have frequently travelled across this space, their courses subject to lateral deviation, covering the whole of it with the coarser fragments brought down by floods at a time perhaps when the water of a lake or the sea, occupied the basin of the finer alluvium and arrested the boulder-bearing velocity of these mountain streams.†

In every part of the alluvium calcareous conglomerate or concrete is of common occurrence. It occasionally contains fragments of bone or fossil teeth of ruminants, but although sought for, no large accumulation nor even a large fragment of these fossils, was observed. Yet enough was seen to show an identity of the conditions under which these deposits and those of the Nerbudda valley were formed. This sub-recent conglomerate is very frequent in the stony tract above mentioned. It was everywhere searched for worked flints but without success, although one flake was found in a quite similar deposit, forming the right bank of the Godaveri at Pyton in the Deccan, at a considerable distance to the south.

Small land shells are not uncommon in the alluvium, some were preserved and transmitted to Calcutta, but in general they were too fragile for removal. They appeared to belong to existing species. Specimens of *Melania tuberculata*; *Paludina Bengalensis*; *Eithinia pulchella*; *Lymnaea*; *Planorbis*; *Unio (?) javidens*; *U. (?)* have been recognized.

* Pronounced Oom'rowtee.

† At one place in the stream near Dhanapoort the stony margin seemed to unite with the finer alluvium by alternations of coarse and fine strata two feet or so in thickness.

‡ The native name for this 'concrete' is "Karruk."



A deposit of varying thickness (within three feet) and but small lateral extent, consisting of fine dazzlingly white sand finely laminated occurs in the alluvial bank of the Poorna at Paruth. It appears to be composed of comminuted or disintegrated crystals of felspars with a small admixture of clay. It did not appear to be formed of or to contain minute organisms, such as foraminifera, and was not elsewhere observed.

Much of this Poorna alluvium produces efflorescences of salts, of soda chiefly, and in many places the wells sunk in it are brackish or salt. Over a wide tract on each side of the Poorna river, north of Akola and thence eastward towards Oomrawuttee, wells are specially sunk for obtaining common salt from highly saturated brine.

Some of these salt wells near Dylunda in the lands of Gunoree are from 120 to 130 feet in depth or probably more. They are sunk through yellow clay, then redder clay, and below this a coarse sand or fine gravel from which the water issues with great force. They are lined with wicker work in order to preserve the pottery vessels, in which the water is raised by hand, from breakage. The crystals of the salt are small and it is rather dirty, but during the "dhūp kāla" or hot season, it can be obtained whiter. The wells are numerous over the tract north of the river and some also occur to the south.

That the alluvium of the valley is of considerable depth may be perhaps inferred from the absence of numerous exposures of rock, as well as from the depth of nullahs and height of the river cliffs. The conglomerate, as usual, occurs in its lower portions, but was observed in some places west of Patulla at different heights in the sections exposed. Its constant or frequent occurrence beneath the rest of the alluvium would not prove its being contemporaneous in all places, as the trap rocks, upon which these deposits lie, cannot be presumed to have had a surface sufficiently even to have permitted this.

Whether the whole of this alluvium was deposited in a lake, or by the river travelling from side to side of the valley under other conditions than at present obtain, does not appear. A former estuarine state of things may be indicated by the salt-bearing gravels, or a large salt lake, but the even though interrupted surface of the alluvium is against the probability of its having been deposited by the Poorna under present conditions; while want of information as to the relative levels, obscures the possibility of determining whether the rocky country about Edulabad may not have formed a natural *bund* flooding the country occupied by the alluvium; certainly the stream through most of this is sluggish, but it seems to be a rather strong assumption, that no greater fall than the height of the river banks where it enters this rocky tract—perhaps on an average not more than 30 feet—takes place within so great a distance as extends between this and the upper end of the alluvium, about or S. W. of Oomrawuttee.

Good water is scarce in this district, in some places shallow 'jhieries'* alone can be depended upon for a supply, the wells being brackish and even the river gravels furnishing brackish water if pierced to any considerable depth. A succession of dry years seems to have greatly reduced the usual supplies of water, and very many of the villages among the hills to the north are deserted, it is said, because the streams which supplied them formerly do not now furnish sufficient water. Not improbably the diminution in the supply has been caused by the wholesale cutting down of the jungles which covered the country before the period of the English Raj.†

The hills and portion of the valley south of the Poorna river have been stated to consist of trap similar to that of the Deccan; all the usual varieties of amygdaloid, zeolitic, columnar, hard, gray, and softer, ashy-looking traps occur, their stratification being very perceptible, and always nearly horizontal.

* This name is applied to small excavations in the sandy bed of a river reaching the water which trickles beneath the surface, and thus becomes naturally filtered.

† Want of water is much complained of at Chikulda. There seems to be no reason why the plateau to the east of the bungalows should not afford a sufficient catchment basin for the station. As the trappean strata of the hill dip N. by W. at 5°, if wells were sunk, the north side of the plateau would be the position to choose with most probability of success. Near the bungalows however the plateau, if such it can be called, is very narrow, and affords a much smaller catchment area, yet even here the hill must contain strata which retain water as it issues from the rocky beds of nullahs, and one well immediately beneath the northern edge of the plateau, and at a considerable height upon the mountain side, is stated never to go dry.

About the Gawilghur range on the north there is a constant dip at low angles in that direction, the lower part of the range being chiefly composed of amygdaloid and soft traps; and hard basaltic beds occurring in greatest quantity among the higher parts of the hills, where such bands may be seen to course along the sides of cliffs and mountains for several miles; a capping of the harder trap remaining here and there on top of an isolated peak or hill, while lower elevations around have less angular and more flowing outlines, being formed of the softer varieties of the trap.

Occasionally along the base of this range, the beds have been thrown into wide curves with very gentle inclinations, their axes dipping but slightly to the northward.

Intertrappean beds are said to occur among the Gawilghur hills; they were only detected in one place, and consisted of hard chert enclosing numerous shells: but though near, this is not properly speaking within the Poorna valley.

Perhaps the most interesting geological feature of this country is the occurrence of a great fault, with a down-throw to the south, which may be very considerable, as it shifts the trap downwards for some two or three hundred feet visible, added to an unknown thickness of the trap which is buried by it, so that trap, of what exact horizon cannot be stated, is brought against the underlying Mahadeva or Bâgh (Tanda)* sandstones. This fault crosses the country in an east and west direction, close to the foot of the Gawilghur range north of Ellichpoor, where the abrupt southern scarp of the range shows these sandstones, occupying the interiors of open curves in the trap like those just now mentioned. The difference of inclination between the sandstone and the traps is but slight, so that their unconformity is, as usual, not very strongly apparent, though it nevertheless exists; the line of contact where the overlying traps rest upon the sandstone, is frequently difficult to see when close by it, though from a distance the difference of coloring and the bold projections of the sandstone outcrop mark it well. The sandstones are chiefly soft or coarse white and even-grained rock, which would doubtless make a good building stone. A large mass of these occurs in the lower portion of the group exposed; above them are conglomerates, other sandstones of similar kind, purple and black shales and flagstones, variegated and white flagstones and shales, and then solid gray limestone with siliceous or cherty nodules of peculiarly rugged aspect; these limestones in some places becoming so variegated as to form what if polished would doubtless be a handsome marble.

In this group of Mahadeva or Bâgh beds dips to the north of 10° and 15° , with others more nearly horizontal, may be sometimes seen; these becoming less as the sandstones finally disappear beneath the Gawilghur traps to the north of the cantonments of Ellichpoor. In the river at Nurrha, north-east of the latter place, the section is somewhat unusual. The ground here seems to have been intensely faulted, and instead of leaving the trap and passing over the fault on to sandstone at the base of the hills, trap is again found north of the general line of fault; then occur several large dykes of another intrusive trap different from that usually met with, between which are masses of the limestone, sometimes resting upon a conglomerate, and tilted in various directions at angles of 35° and 50° . Beyond this disturbed locality the next rock seen is sandstone, horizontal for some distance but soon overlaid and covered up from view by the unconformable trap.

In the flaggy portion of the Mahadeva or Bâgh group, impressions of large plants have been observed, and in the shales and some of the limestones numerous small univalve shells.

Fossils were known to have occurred north of Ellichpoor, as mentioned by Dr. Bradley. These sandstones were known to the late Rev. Mr. Hislop, but seem to have been erroneously considered inter-trappean. Lithologically they frequently recalled the appearance of the sub-trappean cretaceous rocks of Bâgh-Tanda and Rajpoor along the Hutnee river, &c., in the valley of the Nerudda, and it was a disappointment not to find the same, or the same quantity of fossiliferous evidence here, the beds in both places being possibly, or probably, of the same age.

Laterite occurs on the new road from Ellichpoor to Oomrawuttee at a place called Bulgaon or Burgow, about six miles from the latter city. It is more properly a lateritic conglomerate of small pebbles cemented together by iron oxides. It lies horizontally, and has

* Bâgh-Tanda is the name generally used by people when speaking of Bâgh at a distance therefrom.

much the appearance of a re-composed rock, in many places quite incoherent, harder at the top and outside than internally, and the pebbles are all red, bright purple or ferruginous, glazed outside and not recognizable as derived from any of the traps of the country, unless from their resemblance they might be taken to have come from one of the beds of red bole, which are not very uncommon; but then there is no reason why if so derived they should not be intermixed with other trap pebbles. This has all the appearance of a local deposit, does not crop out in some natural excavations near at the same level, and apparently passes away underneath the cotton soil, but being horizontal or nearly so shows for a considerable distance along a sluggish stream which occurs here, occasionally varying in structure so as to become a mottled white and purple rock of some strength.

In one place on the bank of this stream a little cliff shows the incoherent gravel resting upon a soft ferruginous bed, about 9 feet thick, with some lines like those of deposition. Beneath this are 5 or 6 feet of greenish-gray trappian mudstone, very splintery and breaking up into cubical forms so much that it is nearly impossible to obtain a fresh fracture; some harder parts seem calcareous, and have a fracture resembling that of compact limestone. The laterite may be traced for more than a mile in an east and west direction. Near Budja Kaira, on the larger river here, strong vesicular laterite undulates about horizontally, but does not continue down the stream.

Again at Reethpoor lying to the eastward from Oomrawuttee, there is a quantity of laterite in low swelling undulations—with the usual appearance of lateritic ground, a ferruginous more or less smooth surface and occasional hard projecting knobs, but no good sections of the rock.

At Chickulda (the hill station on top of the Gawilghur range frequented by people from Ellichpoor), the plateau upon which it stands and the surrounding summits have a strongly lateritic appearance such as may be seen at Matheran and other summits of the Western Ghats.

These indications of laterite, occurring as they do in situations where the uppermost beds of the trap series might be supposed to occur, may indicate a similar or nearly the same lateritic horizon, which is known to occur among the uppermost, if not actually on the top of, the Deccan traps along the Western Ghats. Otherwise they may be referrible to zones of ferruginous strata more specially lateritic than the layers of red bole trap referred to as occurring in this neighbourhood and on the Deccan plateau; but their limited development and isolated character hardly afford sufficient grounds to reason upon with much probability of arriving at trustworthy conclusions.

The cotton soil or black soil of the Poorna valley, although common enough, as is usual in these trappian districts, has no geological peculiarity here requiring attention. To its development, however, and the fertile nature of soils derived from the trap may be traced doubtless the name which this country has obtained as a cotton-producing district.

On the KUDDAPAH and KURNOOL FORMATIONS: *by W. KING, Junr., B. A.*

The rocks forming the greater parts of the Kuddapah and Kurnool districts in the Madras Presidency have been long known through previous explorers under the names of "Diamond Sandstone," "Clay-slate Formation," &c. They extend over such an immense area, and are found to be so complex in their stratigraphy and so diversified in their relations, particularly among the lower and older groups, that their systematic survey is not yet quite completed, though some years have already been spent in their examination. Sufficient, however, is now known of them to warrant the giving a short sketch of this interesting series of rocks.

The series consists of great thicknesses of quartzites (altered sandstones), slates, trap-flows and their associates, and limestones; and these are found to constitute two (if not more) great and distinct formations. To the older, being so typically and largely exhibited in the Kuddapah district,* the name KUDDAPAH FORMATION has been assigned; while the newer KURNOOL FORMATION derives its appellation from the adjoining district over which it is so very well seen.

* Kuddapah town itself is on shales and limestones of one of the groups in the newer formation.

The area of these rocks, from the Kistnah river down to Naggery Nose,* their southernmost extremity, is about 13,500 square miles. The greatest thickness of each formation, as at present known, is:—KURNOOLS, 1,200 feet; KUDDAPAH, 21,000 feet.

The most interesting feature about these formations is that they are most probably representatives of the great VINDHYAN series of Indian rocks. This conclusion has been arrived at from careful comparisons of typical rock-specimens from either series, and of the recorded observations made during the surveys of each. The VINDHYANS have now been traced as far south as the Godavery river, where it traverses the district bearing its name; and here they are so lithologically and stratigraphically like the KUDDAPAH and KURNOOLS on the Kistnah river, not very far south, that there hardly remains a doubt as to the identity of the one with the other.

The history of the KUDDAPAH is still to be thoroughly worked out; and on this account, the present sketch will be more directly confined to a description of the KURNOOLS. There are, however, some well-marked and clearly made out features of the KUDDAPAH which may in the mean time be adverted to.

Both formations agree in this, that they are largely made up of quartzites, while limestones are sparingly developed in one and extensively in the other; but the KUDDAPAH are distinct in showing strong groups of clay-slates, with one of which it may be necessary eventually to include the trap-flows and their associates referred to above.

Supposing at present that all the quartzites, slates, &c., not included in the following description of the KURNOOLS, may be considered as of the KUDDAPAH FORMATION, it is then possible to give an idea of their locality in the great area of country occupied by this formation.

The Goolcheroo hill-ranges south of Kuddapah, and their extension south-eastward down to Tripurty and the Naggery hills, are made up of quartzite sandstones and conglomerates; while rocks of the same kind with bands of slate go to form the long range of the Eastern Ghats or Yellacondas lying between the Kuddapah and Nellore districts. The country south-east of Kuddapah, that is Ontamitta, Chitwail, Poompmet, &c., within these mountain ranges, and that due north of it:—Nullamullays, Budwail and Cumbum, up to the Kistnah river, are also made up of like rocks of the same formation. The Gundicottah range of hills, north-west of Kuddapah, is likewise of these old quartzites, and the parallel ridges and valleys between that range and the Bellary district to the west, with their extensions right up to Jaggarnat-Conda (hill), a few miles south of Kurnool, are of quartzites, slates and traps.

These older rocks are interesting as being traversed, at rare intervals, by veins and strings of copper and lead ores, accounts of which have from time to time been given by writers on the resources of Kurnool and Kuddapah. Copper ore occurs very sparingly; in fact, there are only traces of it, but the sulphide of lead is more abundant. The workings for both were abandoned years ago; a state of things perhaps due to the difficulties in the way of living at, and working the mines, rather than to a failure in the ore. Traces of these ores are also known in the older crystallines or gneiss, of the remainder of the districts.

With such a brief account of what is at present known of them, the KUDDAPAH may be left for future description.

KURNOOLS.

This formation unfolds itself as a double series of groups of limestones and quartzites; the lowest beds of all being quartzites, as thus, in descending order:—

1. Limestone group	...	...	{ a. Calcareous shales.
			{ b. Limestones.
2. Quartzite group	...	...	{ a. Pinnacled beds.
			{ b. Plateau beds.
3. Limestone group	...	...	{ a. Non-calcareous shales.
			{ b. Limestones.
4. Quartzite group	...	...	{ a. Massive beds.
			{ b. Beds (containing diamond gangue).

* A peak of the Naggery range, about 40 miles W. N. W. of Madras.

These four groups are quite distinct, though conformable; they generally overlap each other in some part of the field, and they lie, for the most part, very much as they were originally deposited, viz., in great flat basins with edges slightly turned up,* or in very flat undulations, from which, however, the upper limestones are always denuded, leaving the quartzites exposed.

1ST GROUP, KHOONDAIR LIMESTONES.

The uppermost group lies nearly all over the wide Khoond-air (river) valley which stretches northwards from Kuddapah town, and over most of the Kuddapah basin or southern extremity of this valley. There is a small outlier under the fort of Kurnool; while more of the same rocks cover the eastern extremity of the Raichoor Doab. Again, a considerable detached area of these beds, with the other groups, occurs in the Palnád, or western taluq of the Kistnah district.

The rock coming to the surface,† especially in the Khoond-air valley, is not, however, always limestones; more generally, there are reddish-purple calcareous shales (occasionally cleaved) and these constitute the upper member of the group. For instance, the shales occur all up the middle, and very strongly at either end, of this great valley. They gradually shade down into the typical limestones of the group, which are dark-gray, more or less earthy, sub-crystalline beds; sometimes very massive and thick, oftener flaggy or easily split up into flags of 1—3 inches in thickness. The limestones are also occasionally more crystalline and compact, and cleaved to a certain extent, where folding or crushing of the beds has taken place, as along the eastern side of the Khoond valley. They of course show most along the skirts of the valley, as near Kuddapah, Podatoor, Dhoor, Chagalmurry, Sirwél, and so on up to the banks of the Kistnah.

2ND GROUP, PANEUM QUARTZITES.

Along the western side of the Khoond valley, the country rises very gently in a series of low long-sloping hills, with a few plateaus and undulations, which finally present an irregular scarp towards the Bellary district. These are the Gundicottah, Ramwarum and Paneum hills, whose surfaces, with the exception of the Gundicottah range, are made up of quartzites of the second group, which thus rises up from under the limestones of the Khoond valley.

This is the only side of this part of the country over which these quartzites occur; they do not appear on the western side of the valley, for the group thinned out altogether in that direction, as well as to the north and south; the sections among the turned up strata on this side showing the upper limestone group lying on the lower one without any intervening quartzites, as is the case in the sections on the western side.

Altered sandstones of the same group show rather strongly in the Kistnah district; where they are again, through the denudation of the upper limestones, the superficial beds of the low hills in the south-west corner of the Palnád.

The quartzites are of two kinds, quite distinct enough as features in the landscape, but hardly sufficiently so to be referred to as separate members of a group. The upper variety is a thick-bedded, massive, compact, white sandstone, much vitrified, but granular, and showing a very peculiar style of weathering into massive buttresses and pinnacles. The strata are generally horizontal, or at a very low angle, and the steep-sided ravines and scarps denuded in these are often fringed with strangely picturesque masses of rock, or the slopes below the scarps are strewn with great fallen masses of the same beds. The high-road from Kurnool to Nundial passes over a plateau of those white quartzites, and the quaintly worn masses immediately remind one of some rocky coast from whence the rushing and tumbling waters have long since retired.

Coarse sandstones and grits, with pebble beds, of dark colors, and in thinner strata are generally found subjacent to the thick, white, pinnacled quartzites, and are often alone without the covering of the upper beds. In such last cases, the remaining beds now form the summits of a number of flat-topped hills fringing the Koilkontla and Banagan-pilly sides of the Khoond valley.

* The subjacent KUDDAPAH are, on the contrary, turned up on end, convoluted, crushed, and faulted in the most varied way.

† The Khoond valley is very extensively covered with coition soil.

3RD GROUP, JUMMULMUDAGOO LIMESTONES.

Wherever the above group of quartzites has been cut through, it is seen to be resting quite conformably on a thick series of shales and limestones; occasionally the shales thin out and nearly disappear altogether, and then the quartzites look to be resting directly on gray limestones.

These constitute the second limestone group among the KURNOOLS, and they are generally easily distinguishable from those of the Khoond valley. The shales are generally of a buff color and are never calcareous, while the purple shales of the upper group are always more or less so; and again the limestones are as a rule more crystalline and compact. There are, it is true, just as earthy and flaggy beds to be found in the upper as in the lower group, but such beds are less frequent in the latter, and they are arranged in definite succession. There is generally a three-fold series, thus:—at the bottom, compact, sub-crystalline gray, and some purplish beds, with a thin series of peculiar limestone breccias; in the middle, thick, compact-splintery dark-gray and bluish beds; and thirdly, pale and dark-gray compact, sub-crystalline and sub-earthly, often flaggy, beds.

The more crystalline and compact beds weather in a peculiar coralloid manner; the worn surfaces being so radiately furrowed, pitted, and concentrically terraced, that the rock seems to be made up of two or three different forms of coral; but close examination has failed to show any organic structure. This coralloid appearance is characteristic of any great show of these lower limestones, though the same feature is also seen every now and then in the upper group.

This generally more crystalline set of limestones is seen at intervals, along the eastern side of the Khoond valley, in a narrow belt of outcrop at or near the western base of the Nullamullays. Again, on the western side of the same valley in Koilkootla and Banaganpilly, and in the valley between the low Nosoom ridge and the Gundicottah hills, and so further south, in the western part of the Kuddapah basin, where the Nerjee quarries* have been opened up in the thin and compact beds of the group.

In the steep western slopes of the Gundicottah, Ramwarum, and Paneum ranges of hills, these limestones again come to light and form a narrow continuous terrace below the vertical scarps of upper quartzites, all the way from the tops of the hills east of Tadpurthee (Bellary district), up to within 24 miles south-south-east from Kurnool, when it spreads out in wide sheets between the lower and gentler undulating hills which are here sinking down to the flat country of Kurnool, itself built on a further out-stretch of these same beds.

Here, in Kurnool, the group has thinned out a great deal, but still there are the three varieties of limestones in their proper order: the canal being cut in thin flaggy upper beds; the more crystalline strata cropping out between the canal and the village of Calloor; and the thin grey compact sub-crystallines, though altered much by local igneous action, showing close under the western bastions of the town. Thence, with the exception of some slight denudation in the Toongabudra and Kistnah, these limestones extend northwards to a few miles beyond the latter river, in the Hydrabad territory.

In the Palnâd there is the limestone again in great force. It here presents identical characters with those in Kurnool and Kuddapah, except that it is more extensively cleaved; and that the white and buff non-calcareous shales are only seen to a small extent.

4TH GROUP, BANAGANPILLY QUARTZITES.

Lowest of all of these strata comes another quartzite group which is interesting as including the beds from which only diamonds are known to have been extracted in the districts under description.

Hence, if the old nomenclature of "diamond sandstone," or "diamond formation" was to be employed in a classification of Madras rocks, it would have to be applied to the KURNOOLS, or one of the groups included in that formation. There is no case known of diamonds having been found in quartzites of the KUDDAPAHs, or in fact in any other group of

* These quarries were opened, and are now extensively worked by E. W. Barnett, Esq., who has used the stone whenever practicable on the Madras Railway, and for the new Madras University and other public buildings in the Presidency.

quartzites but the one now described. It is not, however, advisable to employ a name to distinguish a formation, which is derived from what is evidently only an accidental attribute of the rocks; while it is not certain that the diamond sandstones of *Punnā* in Central India, which belong to the *VINDHYAN SERIES*, are on the same geological horizon as the diamond-bearing beds in the *KURNOOLS*.

This group of quartzites is a generally thin series of coarse sands, grits, and pebble beds, of dark colors; the sandstones being in thick beds, while the grits, &c., are generally thin and sometimes flaggy. The pebble beds are full of small fragments of chert of various colors which are evidently derived from the slates and trappean beds of the *KUDDAPAH*, on the up-turned edges of which they now rest.

The relations and constitution of the group were first made out at *Banaganpilly* in the *Kurnool* district, where the long sloping hill which rises to the west of the town is faced with the quartzites.* From this point the strata were traced to the west, on either side of the *Puspulla* valley, as another narrow terrace of nearly horizontal beds of not much thickness, below and continuous with the terrace of limestones of the second group, already referred to as lying below the western scarps of the *Ramwarum* and *Paneum* hills. Indeed, these lowest quartzites form the toe of these western slopes.

The thin-bedded pebbly strata which are generally the lowest in the group seem to be the holders of the gangue, or shaly seams, in which the diamonds are found, but it is only at rare intervals in the exposed area of these pebble-beds that workings have been opened, which is partly accounted for by the fact that these seams of sandy and pebbly shales are only of local occurrence in the quartzites. The selection of working sites seems mainly to have been guided by chance, as the finding of a diamond by a cooly or shepherd, and the selection has been a lucky one in only some cases, for there are localities where extensive workings have evidently been carried on for centuries; while others have soon been deserted. The diamonds found at present are very small and not of much value, nor do the returns seem to have been any better for many years. The workings are of two kinds; mines excavated in the strata, or pits sunk at various points in the recent deposits of débris, shingle, and gravel, derived from the denudation of the quartzites.† The *Banaganpilly* workings are mainly mines, while the now deserted pits at *Chennoor* near *Kuddapah* were in recent gravels.

In the *Palnad*,‡ there are again a set of altered sandstones answering to this group, and there too among these beds are frequent traces of old diamond workings.

The lowest group of the *Kurnool* formation is always found to be resting unconformably on other quartzites, slates, and limestones; and where it is overlapped by the superincumbent limestones, these in their turn are found covering the older rocks in the same way; in fact, there is not the smallest doubt but that the four groups now described constitute a distinct formation separable by a great interval of time from the subjacent strata, or the *KUDDAPAH*.

Both formations are totally devoid of any fossil remains, at least not a trace of evidence of organic life has been found in their strata, and in this they are like the *VINDHYANS* which are as indicative of a period when there was no life. No more likely series of rocks for containing such remains could be imagined; and one is tempted again and again to examine favourable localities, but always with no other result than some deceptive concretions, or worm-like tracks, or the most perfect surface of ripples in the sandstones.

Neither can it be that fossil remains which may have once existed can have been so completely obliterated by the metamorphic influence to which these rocks have been exposed, as to have left no trace behind; for whenever we have the originally sedimentary constitution of the rock apparently completely baked out of sight, as it were,—as in the case of pebble beds and the coarsest conglomerates, which, until they are weathered, are as uniformly granular quartzites as one could wish to see,—the various weathering influences have again revealed the original constitution.

* The *Banaganpilly* diamond mines are sunk and worked on the slope of this hill.

† These débris-deposits are often quite outside the area of *KUDDAPAH* and *KURNOOLS*, and hence we occasionally hear of diamonds being found in the neighbourhood of granite, or gneiss, when they are supposed to be derived from the latter rocks.

‡ It may be as well to notice that the so-called *Juggiapett* coal-field is a north-easterly extension of the *Palnad* area, and the *Juggiapett* rocks are *KURNOOLS* and *KUDDAPAH* which are not at all of a coal-bearing character.

There are deceptive appearances of organic structure, such as, minute concentrically laminated globular bodies, in some of the KUDDAPAH rocks; the coralloid character of the Kurnool limestones; minute *Cypris*-like bodies in the upper limestones; the dendritic crystallizations of the oxide of manganese in quartzites, limestones, and slates; and lastly the cavities of clay-galls so frequent in the sandstones; but these of course are all referrible to other than organic origin.

GEOLOGICAL SKETCH OF THE SHILLONG PLATEAU: by H. B. MEDLICOTT,
F. G. S., Geol. Survey of India.

The main features of the geology of the Shillong plateau, on the north-eastern frontier of Bengal, have been known for some time: cretaceous, nummulitic, and younger strata, resting horizontally upon metamorphic rocks of various types, at an elevation of 4,000 to 5,000 feet, and doubtfully related to extensive masses of trappean eruptive rocks. A brief opportunity has recently occurred of visiting the hitherto geologically unexplored western portion of the plateau in the Garo region; and also of re-examining the central portion, in the Khasia district, at a season when field work was possible. A brief abstract of the results is here given in anticipation of the more detailed description.

Regarding the supra nummulitic rocks, which are very poorly exposed in the central region, little fresh information has been gained. From the sandstone of Nongkalong on the western limits of the Khasia district, where it rests upon nummulitic limestone, Captain Godwin-Austen has made a collection of fossils upon which Dr. Stoliczka remarks that "none of the species, so far as recognizable, appear to be identical with those known from the nummulitic beds of the same district."

The nummulitic formation presents a total change in the character of the deposits from east to west: from being purely sandy and calcareous, they become almost entirely argillaceous.

The doubtful horizon between the nummulitic and cretaceous formations has been worked out. The former does not overlap the latter; the northern outliers, so far as known, are all of the cretaceous deposits.

The local order of the cretaceous deposits at Cherrapoonji is described.

Many of the fossils collected have been identified by Dr. Stoliczka with forms occurring in the Ootatoor and Ariaaloor groups of the upper cretaceous rocks of South India. In the small collection obtained, there were recognisable eleven forms of Cephalopoda, twenty-seven of Gastropoda, eleven of Lamellibranchiata, three of Brachiopoda, and four Echinoidea.

A very extensive formation of stratified eruptive rocks is exposed, unconformably overlaid by the cretaceous strata and resting in natural junction against a steep face of the metamorphic rocks along the south base of the plateau. It is fully 3,000 feet thick. No inter-trappean sedimentary rocks, nor any infra-trappean younger than the metamorphics, having been found, it is impossible to assign the age of this eruptive formation. It is proposed to call it the Sylhet Trap.

Totally distinct from this is the Khasia Trap, so massively developed in the interior of the hills, associated with the younger metamorphics. It is probably hypo-synchronous with these, *i. e.*, introduced (? formed) at the time of their main disturbance and metamorphism.

The granite occurring, both in large masses and in dykes, through the upper metamorphics is younger than the Khasia Trap.

The separation of the Shillong series (the upper metamorphics) from the Gneissic series, is conjecturally indicated.

The peculiar position of the plateau, between two great regions of disturbance, and the close relation of the stratigraphical features with the south-eastern of these mountain-regions are discussed as illustrative of current opinions upon crust-movements.

The occurrence of a sharply defined terrace of older alluvium round the west base of the Garo hills, and corresponding with the well known Madhoopoor jungle deposits in the plains to the south, is noticed with reference to the changes that have affected the delta of the great rivers.

October 1868.

ON THE OCCURRENCE OF GOLD IN THE DISTRICT OF SINGBHÚM, &c., BY VAL. BALL, ESQ.,
Geological Survey of India.

The existence of gold in the districts of the south-west frontier of Bengal and in the neighbouring tributary states has long been known. It is found not only in the sands of many rivers and streams, but in some instances it has been mined for in the alluvial and other superficial deposits.

Colonel Haughton in his interesting memorandum 'On the geological structure and mineral resources of the Singbhúm Division,'* has given an account of the gold washing, and enumerated several localities where gold mining had been, or was, at the time of his visits, carried on. He also quotes from a letter from Mr. Robinson in which that gentleman states the results of his attempts to establish gold-mining under European superintendence.

At Rohobe in Oodipur where operations were commenced and shewed some prospect of being fairly remunerative, the climate proved so "hot and unhealthy" that it was found that no European could live there, and the works were given up.

Colonel Haughton says that "the metal was found some years ago in considerable lumps in the Sona Nuddee of Sonapet in Tamar on the northern extremity of Singbhúm, "and much is still found there."

I have invariably found that the washers have traditions of nuggets having been found at intervals.

The cases of the gold having been found *in situ* are undoubtedly rare. Colonel Haughton speaks of it occurring in (*in situ*) "a little north of Assuntilea in Khursowa," but further on he states "I have not heard of any instance in which the metal has been found attached to a stone, so that the former statement must only mean to imply that it is mined for in superficial deposits." Dr. Emil Stehr states† that traces of gold were found in the copper ores of Singbhúm.

A Mr. Emerson was specially employed by the Singbhúm Copper Company to investigate the gold resources of the country. He is said to have crushed a quantity of quartz and to have found traces of gold in it; but his operations do not appear to have been sufficiently successful to encourage him to continue.

When in Chaibassa last April, I was shewn a small nugget of gold in a quartz matrix. It was said to have been obtained in the Kappergudee Ghat near Kalkapur in Dholbhúm.

It is not within the scope of the present paper to give a complete resumé of all that is recorded on the subject, but rather to give an account of what has actually come under my own observation in those portions of the districts which have been examined geologically.

During the season of 1866-67, Mr. Ormsby and myself fancied we were able to connect the occurrence of gold in the streams with the existence of certain submetamorphic rocks (magnesium and mica schists, slates and quartzites) which were then for the first time met with in Mānbhúm.

Being anxious to put this connection to as rigid a test as circumstances would admit of, and wishing to define, if possible, the exact boundaries within which gold certainly exists and may be reasonably looked for, I with some difficulty persuaded two gold washers (man

* J. A. S. B. XXIII, p. 103, 1854.

† Einige Bemerkungen über den District Singbhúm in Bengalen. Viertel Jahrschrift der Naturforschenden Gesellschaft. Zurich, 5th year, Part 1, 1860.

and wife) to accompany me during my examination of the remaining portion of the district of Mānbhūm. They remained with me for upwards of three months, washing daily at such places as pointed out.

One of the most interesting results is, that the existence of gold in the metamorphic as well as the sub-metamorphic rocks has been satisfactorily proved. This, from various reasons, I was not prepared to expect. Colonel Haughton, who speaks of the granitic gneissose rocks as *igneous*, states that gold is never found in the streams traversing them. Again, the Natives, so far as my experience goes, do not wash in the sands, &c., lying on the metamorphic rocks, although they do not connect the existence of gold in the sands with the vicinity of any particular rock.

In Mānbhūm, the experience of generations of washers has enabled them to define the boundaries within which washing is remunerative; and this boundary, it is interesting to observe, corresponds on the north exactly with that of the sub-metamorphic rocks.* This coincidence I ascertained in the following manner. On my arrival at Dulmi (which is situated on the faulted boundary of these two groups of rocks) when marching northwards from the lower part of Pattrum, the gold-washer asked to be allowed to return to his own country (Dhalbhūm), stating that none of his race ever went north of Dulmi. I induced him however to stop, and while we remained north of the fault the washings were carried on in the granitic gneiss area with comparatively poor, but not exactly barren, results. On the day I crossed the fault south of Sindaree, when returning southwards, the gold-washer said that we should after that find gold more regularly and in greater quantities than we had done since we came north at Dulmi.

During the whole time, a record was kept of the daily results and of the nature of the rocks in which the washings were made. The following abstract will suffice for comparison of the productiveness of the two formations:—

Sub-metamorphics.

	January.	February.	March.	April.	TOTAL.
Number of days on which washings were made	31	9	18	8	66
Unsuccessful days	2	3	2	2	9 = 36 per cent.
Gold in grains	17.68	4.65	7.6	2.45	32.88
Daily average in grains ...	.57	.516	.4	.3	Daily average for whole period = .46 grains.

Metamorphics.

	January.	February.	March.	April.	TOTAL.
Number of days on which washings were made	20	18	.....	33
Unsuccessful days	13	9	.....	22 = 66 per cent.
Total gold in grains	4.78	.7	.....	5.48
Daily average23	.06	.....	Daily average for whole period = .46 = 33 = .16.

* A line drawn across the southern part of Mānbhūm from Simlapal on the east through Burrabazar to a little north of Echagurh on the west, roughly indicates the position of the line of boundary between the two formations.

Comparing these results by the number of successful days first, we may say, that for gold producing, the submetamorphic rocks are to the metamorphics as $(100 - 13.6 = 86.4)$ to $(100 - 66 = 34) = 2.5 : 1$; comparing by daily average, the proportions become $.46 : .16 = q. p. 3 : 1$.

We may therefore conclude that the submetamorphics are between two and half and three times as productive of gold as the metamorphics, so that as the gold washers only find a subsistence from washing in the submetamorphic area, it is obvious that it would not pay them to work in the metamorphics.

The greatest amount found on one day was 2.2 grains, but the daily averages given above should not be taken as indicative of the amount of gold to be found by a regular system of working where the washers would of course be set at favorable spots, and would not have to spend a considerable portion of their time daily, as was the case of the men I employed, in making marches before they reached the scene of their labours.*

Various papers in the Asiatic Society's Journal describe the methods of gold-washing practised in different parts of India. The instruments used, though essentially the same in principle throughout, have local peculiarities of shape, &c., and the manner of manipulation also varies.

At Heera Khund† the same instrument and manipulation serve for the separation of both diamonds and gold. In fact the diamonds are found in the middle of the process, the iron sand with specks of gold being the final residue.

In Mánbhúm and Singbhúm the instruments used are perhaps more simple than those used in any other place. The dish measures 28" by 18", it is hollowed somewhat eccentrically to a maximum depth of about $2\frac{1}{2}$ inches. A scraper formed of a flattened iron-hook set in a handle, serves to collect the auriferous sand and gravel which accumulates in the angles of the rocks in the beds of streams. The dish when filled is placed in shallow water, and the operator working with his hands soon separates and throws aside all the coarser gravel and stones, while the agitation of the water serves to carry away all the mud and lighter portions.

The dish is then balanced on the palm of the left hand and oscillated to and fro with the right; this serves to throw off the greater portion of the remaining gravel, and the process is completed by a circular motion, which is communicated to the water in the hollow of the dish, by which even the smallest particles of foreign matter are separated, and the final result is a residue of black iron-sand in which the specks of gold are readily apparent.

The gold-washers belong to the lowest and poorest races in the country, Gasrees according to Colonel Haughton, but some of those which I met with were a race of kumars, called Dokras. Their numbers have been greatly reduced by the famine; without exception they are all in the power of the Mahajuns, for whom they work at a low rate, and are never able to free themselves of the claims which the Mahajuns make on account of advances.

The daily earnings of the gold-washers are small, but might no doubt be increased, if it were not that they are always satisfied when enough gold has been found for procuring the day's subsistence.

* It is conceivable that the fact of the greater quantity of gold being found in the superficial deposits within the submetamorphic area might be attributable to something in the configuration or elevation of the ground conducive to the greater accumulation of gold within that area. I could not however discover anything of this kind; the fall to south is gradual throughout both formations.

† The origin of the gold which is annually found in the rivers at present is, I believe, twofold. A portion being directly derived from the rocks and the remainder resulting from the re-assortment of detritus which is the remanent of sub-aerial action.

In both formations, the evidences of extensive sub-aerial action are numerous and prominent, and it is obvious that nature has been carrying on gold washing operations in the valleys, since denudation first commenced to scoop them out, leaving barriers of intervening ranges of hills formed of the hardest rocks between them.

Colonel Haughton says—"The Gassees can always reckon on earning from three to four pice per day, and I am assured that a vigorous man often gets as much as twelve annas, which, as the ordinary rate of field labour is about one pice, must be considered a very large sum."*

Mr. Robinson found in a trial which he made at Rohobe in Oodipur, that men to whom he paid one anna could produce for him from three to four annas worth of gold.

Colonel Dalton states that the washers themselves regard it as a very poor trade, simply yielding they say *pét bur* (bellyful).

Dr. Steehr in his paper on Singhbhūm states that he found the average daily earning to be about 25 centimes (rather more than an anna and a half).

The men I met with stated that they could earn about an anna a day and occasionally three or four annas.

Taking into consideration the manner in which the gold is distributed through the superficial deposits of these districts, it would seem that the system of hydraulic mining, at present practised in California, is the one which would be most likely to be successful.

In a recently published account† of that system we learn that there is a company in California which supplies water to the miners at such a moderate rate that "350 miner's inches of water, with a head of 160 feet, will remove and wash 4,000 tons of gravel per diem, leaving a small profit on the working of stuff affording gold to the value of only three half pence per ton."

In parts of the districts under consideration it would be hopeless to expect to obtain a constant and sufficient supply of water with the necessary head-way: but there must be many places at the bases of the plateaux which rise towards the west, where the conditions would be peculiarly favourable. During the rains the number of such places would of course be vastly increased.

The simplest idea of this process, which seems so nearly to approach to perfection in California, is not, however, altogether unknown to the natives. Mr. Robinson says‡— "Another plan and a very remarkable one in which the people collect the gold is by drawing up small watercourses before the rains, so as to make places for a deposit of soil carried down by the water; this soil is cleared out several times and in it is found a large deposit of gold."

In the shallow diggings the hydraulic system would not of course be applicable, but even in them an increased field would undoubtedly result from supplanting the native's dish by the Californian pan, rocker, long-tom and sluice.

September, 1868.

MEMORANDUM ON THE WELLS NOW BEING SUNK AT THE EUROPEAN PENITENTIARY,
AND AT THE SITE FOR THE CENTRAL JAIL, HAZAREEBAGH, by H. B. MEDLICOTT,
F. G. S., GEOLOGICAL SURVEY OF INDIA.

1. All the rocks of Hazareebagh are of the most extreme metamorphic type, and are besides very irregularly arranged. It will, therefore, be at once understood that a question of water-supply, in which these rocks are concerned, is altogether beyond those simpler cases where a study of the sections might enable a Geologist to give an approximate positive judgment upon the source of water in any given position. The independent method being thus not applicable, I had to trust to the discussion of existing local experience, and the comparison of this with the special cases proposed, with the following results.

2. Hazareebagh is on an undulating upland. There is nowhere any strictly level ground; but the tops of the ridges are generally very flat, and the slopes very gentle. It

* J. A. S. B., 1854, p. 109.

† Quar. Journal of Science, XIX, July 1868.

‡ J. A. S. B., 1854, p. 103.

is only in the immediate neighbourhood of the main stream-channels that rougher and steeper ground occurs, and also where rocks come to, or near to, the surface, whether on the slopes, or on the ridges. But even in this latter case, the summits of such ridges are very approximately on the same level as those where no rock is to be seen; I regret that available information does not enable me to give figures. Over large areas, as in and about the Station and Cantonments, no rock whatever is exposed. From the few glimpses I was able to get in the upper part of unlined wells or in ditches, it would appear that such areas are formed of a dark stiff sandy clay, tinted with iron, and mottled with concentrated granules of the same in varying proportions. The greatest thickness I was able to observe of this stratum was 14 feet in a partially dug well, where the water level had not yet been reached; but, no doubt, it locally attains greater dimensions. I could not fully satisfy myself, from an inspection of this clay, whether it is purely derived from the decomposition in place of the subjacent rock, or whether it be in some manner alluvial, a point that would bear importantly upon the under-ground distribution of the water. I incline to the former view; but, if correct, the rocks must be there unusually free from the quartz-veins which occur so abundantly in the exposed rock sections, and which veins would remain in position and unaffected in the clay. This stratum forms a cold and retentive under-clay: the upper two feet or so of a paler colour, where de- and re-composition has further advanced, forms a slightly improved sub-soil, yielding at the surface a very poor soil. Where the iron and the sand are not in excess, the under-clay forms an excellent brick-clay; the upper layer being fit for tiles. Below this clay, I am told, there comes suddenly an unknown thickness of incoherent sandy or gravelly material, in which the water runs freely; but from the very apocryphal descriptions I have received, I am quite unable to say whether this be a diluvial deposit, or merely disintegrated rock in place; what has been conjectured regarding the clay may show that I incline to the latter view: the evidence of any old heaps or of well-clearings is in favor of it. The greatly preponderating rock of the region is a finely granular hornblendic gneiss. From a list of measurements taken in 42 wells within Cantonments, and a partially contoured plan, both furnished to me by the Executive Engineer, I have made the annexed tabular statement, from which a few inferences may be gleaned. In none of these wells, that I could hear of, was anything like *rock* met with.

3. It is remarked on the list that "those measured in the evening have often been largely drawn upon, as No. 14 on the south side of the Plunge-bath. Early measurements for all would have been better, even if it had to be done on consecutive days; it would seem, however, that the discrepancies thus introduced may balance each other in the averages of the several groups; but the data being thus not comparable, and there being no collateral information, one is left without a clue to an explanation of what may be only apparent anomalies; such as Nos. 26 and 27, deep wells, exhausted, while much shallower wells in the same neighbourhood hold several feet of water. In all such statistics, the original depths to which the wells were sunk should be the measure given; this ought to be in a permanent record and with it some attempt, however rough, to describe the materials cut through. All should, moreover, be easily referrible to the level of the lowest drainage point of the region as a datum line.

4. The table, contrary to what might have been expected, shows no decided advantage in the supply to wells at a lower level.

5. There is a very marked advantage shown, as was of course to be expected, in an increase to the depth of the wells; there is at least 6 inches gained in the daily supply for every foot in depth below a certain point. I say *daily* supply, for I do not think that the depth of a well would affect its permanent level: thus Nos. 2 and 3 are within 70 yards of each other, neither was much in use; and although No. 3 is deeper by 8 feet 6 inches, there is only 1 foot 3 inches difference in the water level, and even this is in favor of the shallower well. From every consideration it is manifest to me that to have an unfailing supply of the best water in Cantonments, it is only necessary to sink a few feet lower than has been the practice, and, I might add, to adopt some less primitive mode of drawing water than that of hauling in buckets. Where there are only a few feet of water, this mode of raising makes it turbid and unfit for immediate use. Serious difficulty seems to have been felt in attempting to carry the wells even to their present depth; but I cannot find that any proper means have been tried to overcome this difficulty, such as the use of some method of shoring up the sides while the work is being carried on in friable, watery ground, and at the same time some means of unwatering more effectual than the obstructive one of baling and hauling.

6. Several figures in the list show how safely the water is stored below; how slowly, but surely, the supply recovers when drawn upon. These measurements were taken on the 5th of June, after a long season of drought. Dr. J. M. Coates, Superintendent of Jails, has kindly given me a statement of the rain-falls for the preceding months:—January, 0'26; February, 0'97; March, 0'64; April, 0'0; May, 1'54; up to 5th June, 0'59. The scarcity was much felt, but it was not an extreme case. I am told that worse seasons have been experienced, still there were 13 and 20 feet of water in wells Nos. 2 and 3 at a depth from the surface of 26 and 27 feet. In other cases, as Nos. 6 and 14, a fair daily supply was renewed nightly. The stratum of clay can be but very slightly permeable to water, and can contribute little; all the evidence goes to show that the water is lodged in the disintegrated upper portions of the under-lying gneiss. The depth to which this decomposition takes place is variable according to the variety of the rock in different spots; but it is generally very considerable, and in every case I would take that as the depth to which a well may be sunk with advantage. The moderate permeability of this rotten rock, as shown by the facts just quoted, suggests an alternative to the deep sinking which has been recommended as the best safeguard against scarcity: it would seem that wells may be sunk within 80 to 100 yards of each other without seriously affecting the daily supply in each within the limits of ordinary demand.

7. In connection with the question here discussed, I would bring to notice an allied one of equal importance. In the 13 days following the 6th June there fell 14'43" of rain, and all the wells were filled to within a foot of, or were quite up to, the surface. This is their condition for months throughout the rainy season, after which they slowly subside to their minimum at the end of the ensuing hot season. Such a state of things will seem strange after what has been said of the configuration of the ground, that the surface drainage is ample in every direction; and that at no great distance the rocks outcrop in valleys much below the general level of the country, unless from artificial causes there is no surface lodgement of water. It may seem stranger that it should be allowed to remain so. I have lately heard doubts expressed as to the reputed healthiness of Hazareebagh. Without in the least wishing to endorse such an opinion, against which there is much presumptive evidence, I may remark that, according to received notions, it seems like neglecting a means of improved healthiness to allow the water to be so near the surface. It may be said, and I am not prepared to deny the assertion, that so long as the water is even a few inches under ground, it is innocuous; that it is only when allowed to stagnate on the surface that it becomes injurious; if it be so, most of the ground would require no treatment, but there would remain much to be done. When I passed through Hazareebagh in the middle of November 1866, after we had many days of hot sunny weather, I noticed soft sludgy ground in many places, even within a short stone's-throw of the barracks. At half-way down the slopes of the shallow hollows the water does ooze out, creating this boggy ground, so long as the general water level remains above the level of the channel. Surely this would come within the limits of the conditions to which the autumnal unhealthiness is attributed all over India. But here, not as in the cities of the plains, the remedy is easy; the most complete facilities exist for drainage of any required degree. Of drainage, such as is usually understood in India, Hazareebagh has had its fair share: the natural water channels and the cuts along the roadside, or elsewhere, are kept clear, but in such a sub-soil as that here the effect of this is imperceptible. Drainage to be effectual should be such "thorough drainage" as a farmer would apply to similar land in Scotland, if he wanted to bring it under tillage.

8. The Civil Station adjoins Cantonments immediately on the north-west, the ground being apparently slightly higher. Here, about the Zillah-Jail, and in the grounds of the house occupied by the Superintendent of Jails, I saw some sections in unlined wells somewhat different from what would seem to be the rule in Cantonments, in so far as that the clay, which is of precisely the same character as elsewhere, is much less thick, not more than 6 to 10 feet. The rock does not appear at the surface. Even here I could not satisfy myself upon the mode of origin of the clay; there seems to be generally at the base a foot or so, in which coarse quartz debris is abundant and irregularly scattered. Here, however, it is certain that the water-yielding rock is the porous rotten gneiss, in which the wells are dug without any difficulty. It is often so loose as to crumble away and fall in.

9. We may now come to the main object of our investigation. The European Penitentiary stands about three-fourths of a mile to north-north-east of Cantonments, and separated from them by a broad valley, some 40 feet deep, passing up to westwards, in which

direction the ridges are confluent. The site for the Central Jail is some few score yards beyond the Penitentiary, on another minor branch of the same system of ridges. In both localities rock crops out freely in many places, and it might have been anticipated from the beginning that the well question would assume a very different aspect from that of any case within local experience. It were useless to moralise upon so common an occurrence as want of foresight, or to indicate its source in this particular instance.

10. In the Penitentiary well there is no clay at top. After about 3 feet of coarse quartz gravel, mixed with red sandy earth, they come upon a run of largely crystallized granite (pegmatite) very irregularly associated with hornblendic gneiss. At first this mass was not difficult to be cut, although not nearly so soft as the rotten rock already spoken of, but it rapidly became harder, and at about 20 feet blasting had to be resorted to. All effects of decomposition from surface atmospheric influence having ceased, the stone showed its true characters of intense hardness and complete impermeability. The arrangement of the bedding, if, indeed, it be true bedding, in this short shaft is exceedingly irregular, at one spot apparently dipping to the north, and at another to the west. In the hard rock at base there are some well marked joint planes showing large flat surfaces nearly vertical, but these joints do not seem to be available for the percolation of water; the few leakages that occur are from points in the indefinite cracks that traverse the stone discontinuously without any system, and generally where there is a film or layer of partially disintegrated rock. Near the base of the shaft another vein of granite like that at top, but thinner, traverses the gneiss irregularly at a low average angle, but here it is firmly united with the containing rock, the same even surface of fracture passing indiscriminately through both. I waited for several days to have this well emptied, but the water was still knee-deep at my last examination. I do not consider that I have lost any evidence of importance.

11. From the accounts I have received, there would seem to be some prospect of immediate success. I am informed by Dr. Coates that a few days before the work closed at the end of the hot season, he made a rough measurement of the leakage water, and found it to be about 40 gallons per hour, nearly 1,000 per day. I confess that this surprises me much: the excavation then was at about the level the water stood at when I saw it last, and the leakage did not seem to me any thing like so much, although the time of year was so much more favorable, and the well had just been emptied by double gangs of men working day and night. Subsequent to that measurement, the last few blasts put into the rock disclosed one or more layers much softer than any met with for some yards above, and from which water flowed in much greater abundance than from any of the higher points. Unfortunately the rains put a stop to the work before this ground could be fully proved. The only symptoms I could detect of these sources was that, in walking about through the water, I felt at two or three spots a very appreciable warmth under my feet. The first thing to be done now is fully to test this ground. Five or 6 feet more of cutting ought to prove what it is worth. But a large margin ought to be left above any measurement made now for the diminution that may be expected in the dry season.

12. There can, of course, be no doubt of ultimate success: accumulated drippings will at last yield the required supply. But this must remain matter of experiment. No one but a diviner would venture to predict at what point success would be attained in rocks like these. There is, however, an evident choice as to the direction in which these contributions are to be sought. That word "spring" has a great deal to answer for: most men seem to think that water comes from the bowels of the earth, whereas in 99 out of 100 apparent cases the source is from above. The only available, and the only known, source of water here is the one already pointed out, the porous mass of disintegrated rock at the out-crop under the clay. This being the case, I would decidedly recommend, in the event of the next few feet in depth not giving the required supply, that the vertical shaft be changed for a nearly horizontal drift. The chances are almost all in favor of this plan, and there is here the ultimate certainty of tapping the source itself in the most effectual manner from below. In the vertical shaft there is no doubt the chance of contributions from every side, while in the drift we must select the most likely direction, but I am in favor of this attempt. There are two elements for consideration, the structure of the rocks, and the lie of the surface. From what has been seen of the rocks in the Penitentiary well, there is little or no room for choice; they have no definite arrangement. The most frequent run of the rocks in this neighbourhood is about north-north-west, and so the most likely line to cut them would be at right angles to that direction. The *prima facie* view of the second condition would

TABLE II.
Table of measurements in the new Jail Wells.

		Depth of Well,	Depth of Water	Depth of Water
			on 19th June.	on 10th October.
		feet.	feet. inches.	feet. inches.
A. Police Well	... ... ... ... ...	30	28 0	22 6
B. Penitentiary, 1'-9" below A.	... ... ...	56	38 0	43 6
C. Central Jail, 4'-0" n. n.		39	31 6	31 0

METEORITES.—To the collection of Meteorites in the Geological Museum, there have been two valuable additions during the past three months. One of these, a specimen of the very interesting fall which occurred on the 11th July 1868, at Ornars (Doubs), in France, has been presented by M. Jules Marcou, Paris. It is a remarkable stone of a dark-grey colour, oolitic or sub-oolitic in texture, very friable, so as even to crumble under the action of the fingers. Iron is present in extremely small particles. It is very slightly magnetic. In fact, the fall represents a state intermediate between the ferruginous and the non-ferruginous falls, sp. gr. 3.599 (in fragments). It yielded to Pisani by analysis no less than 75.10 per cent. of Peridot. To the kindness of my good friend M. Marcou I am indebted for this interesting specimen.

The second fall occurred in India, near Mooltan, on the 17th October. The fall took place at a spot about 12 miles east of Lodran. "About 2 p. m. a loud report was heard in the sky to the westward, and immediately a cloud of dust rose from the ground. On going to the spot the arolite was found. The sky was quite clear at the time." This is the account given by Captain Bond, District Superintendent of Police.

A portion only of the mass was obtained and forwarded. It is a very beautiful stone, consisting of a large proportion of bright yellowish green olivine, the crystals of which are imbedded in a kind of crystalline net-work of brilliant iron. The stone is at present being analyzed, and the result will be given hereafter.—T. O.

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RECORDS
OF THE
GEOLOGICAL SURVEY OF INDIA.

VOL. II, Part 2,

1869.



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RECORDS

OF THE

GEOLOGICAL SURVEY OF INDIA.

Part 2.]

1869.

[May.

ANNUAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA AND OF THE MUSEUM OF GEOLOGY, CALCUTTA, FOR THE YEAR 1868.

In reporting the progress and doings of the Geological Survey of India during the year 1868, I shall take each branch of our labors in the same order as I have for the most part observed on former occasions.

Mr. W. T. Blanford has, during the whole of the year just past, been engaged with the Abyssinian Field-force, and since its return in arranging and examining the large collections he made during the expedition. Mr. Ormsby was compelled to leave for Europe early in the year, having suffered from exposure to the tropical sun. And Mr. Charles Oldham left on furlough in November. On the other hand, Mr. Tween returned to his duty in charge of the Museum here. Mr. Foote resumed his labors in Madras, and Mr. Theobald in Burmah. On the whole our numbers have been, during the past year, less reduced than usual in consequence of ill-health.

At the commencement of the year, I proceeded to the Madras Presidency to make enquiry on the spot into the facts regarding the asserted occurrence of coal close to the town of Juggiapett, or Battavole, near the Kistna River. For years it had been persistently repeated that coal had actually been raised in that neighbourhood, and this statement was maintained notwithstanding the fact that very many persons, deeply interested in the result and most anxious to confirm the discovery if possible, had visited the localities, but had entirely failed to find any trace of evidence that coal existed or was likely to exist. Its occurrence in this place would have been of such high importance, that I was desirous of visiting the place as soon as practicable; I had also received from the Madras Government an urgent request to enquire into the facts. This request had reached me at a time when field-work was not practicable, but I had promised to go there as soon as possible. I left Calcutta, therefore, early in January; and accompanied by the original propounder of the discovery, I visited carefully every locality which he indicated, and went generally over the district. I regret to state that I found no trace of the coal-bearing rocks; no signs of coal, or of any of its usual accompaniments, nor was I able to see a single spot where anything, in the slightest degree leading to the conclusion that coal did exist there, could be found. On the contrary, all these rocks are an unbroken and uninterrupted continuation of similar rocks which cover an enormous area in the districts of Kurnool, Kuddapah, and Guntor to the south, and which, thoroughly exposed as they are in their many folds, contortions, and disturbances throughout this area, must have exhibited any beds of coal or coal-shale which possibly existed. But, neither in the Juggiapett country, nor over the many hundred square miles to the south, over which similar rocks extend and which have all been carefully examined, has any trace of such deposits been noticed. I was, therefore, compelled to believe that the statement of coal having been found at or near Juggiapett was either based upon an intentional deception practised on the original observer, or was a delusion.

From the vicinity of Juggiapett, I proceeded southward, devoting some time to carefully testing the accuracy of the geological mapping of a considerable area which had been previously examined by Mr. C. Oldham and Mr. King, and returned to Calcutta.

Towards the close of the year (December), I proceeded to Attok to examine the rocks of the River Indus, through which a tunnel drift had been carried, with a view to determine the practicability of enlarging this drift into a regular roadway. I had wished to accomplish such work earlier in the season, but as the tunnel was full of water, and was not pumped out until December, I was obliged to defer it. Having already reported in some detail on this occasion, I need not here enter into the facts, further than to state, there appeared nothing either in the structure or in the composition of the rock-masses to prevent the immediate enlargement of the drift with perfect safety, provided proper precautions were adopted, and the work were done at once. But that these precautions would render the cost of the tunnel, when completed, quite as great as that of a first class bridge, and that even then the accommodation to the traffic would certainly not be as great as that afforded by a bridge.

Subsequently, at the request of the Government of the Punjab, I examined with some care the range of hills near Futtijung, extending southward from Cheerat, and in which petroleum had been obtained. I saw everything to lead to the conclusion that petroleum would be found over a large area in these orbitolite limestone rocks, although probably not in any very great quantities in one place. The best position for trials seemed fairly indicated, and these I noted. The probability would seem to be that limited reservoirs of this oil will be found at no great depth from the surface, although I am not very sanguine that they will prove very extensive in any one locality. Similar rocks occur again in a rudely parallel range to the east, and here also traces of earth-oil are seen; and it would appear very probable that supplies will be found extending over a large area in this part of the Punjab.

An examination of the Dhurmsala district, and also of the Georgiaon district near Delhi, was requested, with a view to determine the extent of deposits of kaolin said to occur in each. Looking, however, to the inaccessibility of both and their distance from any markets, which must prevent the economizing of this clay to any large extent; and also to the fact that, so far as any local demand existed, it was of no importance to determine at the present the extent of these deposits, their existence being known, I felt compelled to think this enquiry was of vastly less importance than others. And that, so far as any question of extent or amount of such deposits was concerned, a very much more satisfactory answer could be given after the whole districts had been gone over than after a rapid visit to one or two isolated localities. No mistake can be greater than to imagine that a geologist can, by a sort of intuition, arrive at a knowledge of facts bearing on such questions. This can only be acquired by a continuous and detailed investigation necessarily demanding time.

BENGAL AND UPPER PROVINCES.—During the early part of the year just closed, Mr. Medlicott was engaged in the investigation of the western and southern flanks of the Garo Hills. So long since as 1842, Mr. Bedford, who had surveyed parts of this area, announced the occurrence of coal in the hills bordering the Bramahpoora River at the western extremity of the Garo Hills, near to a village called Harigaon, and other outcrops had been noticed further to the east in the Sumesurri River. The peculiarly favorable situation of these places, within easy reach of a great river, and in districts where fuel was otherwise not readily procurable, rendered it of high importance that the facts should be ascertained. It was also known that the rocks which accompany coal in the Khasia Hills extended to the west, and there was, therefore, a probability that the coal might also be found to extend in the same direction. It had long been hoped that a topographical survey of these hills would afford the means of recording carefully the geological observations, but as there appeared little likelihood of these hopes being realized within any reasonable time, and as meanwhile the question of the eastern and northern extension of the Eastern Bengal Railway was urgent, it was determined to examine the area, in such a general way as might be sufficient, without entering into minute detail, to solve the question satisfactorily of the probable amount and character of the coal which occurred there. Mr. Medlicott's report on the results of his examination having been published (*Records of the Geological Survey of India*, Part 1, 1868, p. 11), it is unnecessary to enter into any detail here. It will be sufficient to state that he has shown that the spurious coal of the Garo Hills is geologically distinct from most of that known in the Khasia Hills; that, in all cases, this coal occurs near to the base of the whole stratified series within a few yards of the underlying crystalline rocks; while the coal itself is very poor, in one place mainly a resinous shale, in another, a thick bed of dark stiff clay with insignificant strings of lignite through it. Where in greatest quantity, it is described as a thick band of shale in the midst of which

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occurs the coal-seam: it is a good deal crushed, altogether about three feet thick, but very unequally carbonaceous, being locally split by strings of clay and sand; and contains but few thin strings of coaly substance. The mass of what would be extracted as coal is a highly resinous batt or shale, full of small nests and strings of a kind of amber; it gives a wooden sound when struck, is very tough, and breaks with a large conchoidal fracture. It was obvious that whatever little use might be made of such deposits, if required on the spot, they were practically of no value as a source of fuel for general purposes. It is most seriously to be regretted that the statements upon which expectations of coal had been founded should have proved to be so fallacious.

Having completed the cursory examination of these rocks, Mr. Medlicott devoted some time to a more careful examination of the Khasia Hills, for which portions of the topographical survey maps were ready. These very interesting hills had never before been visited by any of the officers of the survey at a time when it was possible to examine the lower parts of their steep slopes; and consequently, as pointed out long since, much remained to be done, before we could suppose that we possessed any true knowledge of their structure. Further, the full determination of the cretaceous age of the sandstones, &c., under Cherra Poonjee, (*Quar. Jour. Geol. Soc. London*, 1863, p. 524, Oldham, on cretaceous rocks in E. Bengal) which, in my own early description, in consequence of their apparent continuity and conformity, (the fossils collected having been lost at sea) had been grouped with the tertiary rocks above, rendered it necessary to carry out this separation in detail. Mr. Medlicott has been able to do much towards this, and in tracing out these rocks has been led to several very valuable conclusions, a brief summary of which has already appeared in the Records of the Survey. As soon as the topographical survey of these hills is completed, I hope to be able to have them examined in detail.

Later in the season, Mr. Medlicott having arranged for the several duties assigned to the assistants under his charge, was requested to take up the very important geological question of the extent and relations of the several series of sandstones, &c., associated in Bengal with the coal, as compared with those in Central India. With this object, making a rapid traverse of the Ra nighunj field, and passing westwardly by the Hazareebagh fields, he has carried out the section across to Jubbulpore, and with very valuable results, which will tend much to a clearer understanding of the different groups or formations. In a new country, where the general relations of the rocks is quite unknown, it becomes necessary for each observer to form for himself a classification of the rocks he examines, grouping them into series or formations, and often giving to these sub-divisions local names. But as the examination of the country advances, it not unfrequently happens that such classification is proved to be of purely local type, and it is essential either to increase the sub-divisions or to bring several together into one larger group. Mr. Medlicott's traverse of this wide extent of country will go far, I believe, to remove, in several cases, the limited amount of confusion which had unavoidably arisen from the fact that previously the officers of the survey had been working at distant and isolated points.

Mr. Willson has completed the detailed examination of the district of Saugor in the Central Provinces, which he has connected with those of Dumoh and Jubbulpur to the east. Unfortunately the want of maps of the country lying to the west of Saugor district has prevented the extension of our examinations in that direction, as I was very desirous of doing, in order to join on the geological lines to those we have been for some time past steadily carrying southwards through the Gwalior and Rajpootana territories. The district of Saugor is mainly composed of trappian rocks, which are, in this parallel, the most northerly portion of the Great Deccan area of these ancient volcanic rocks. These rest upon Vindhyan rocks for the greater portion of their boundary.

Mr. Mallet has, during the early part of the year, completed the examination of the crystalline rocks of Bundlaund—being a continuation of his work of the previous year—so far as the area occupied by these rocks is comprised on sheet 70 of the Indian Atlas. The further explorations of this year have rather induced Mr. Mallet to abandon the idea of separating these rocks into two series as was suggested in 1866-67. The evidence, however, is even yet scanty, and not conclusive. And it must remain for more careful investigation when better maps, on a larger scale, of the Bijawur area become available. The maps, at present procurable, are too imperfect to admit of any close or searching examination and record.

During the recess, Mr. Mallet completed a full report on the Vindhyan rocks, so far as that widely spread formation is known in northern India up to the present. A general map has been compiled to illustrate this. This report has been sent to press. At the commencement of the working season in October 1868, Mr. Mallet proceeded to take up the detailed examination of the eastern part of the Sone Valley, and is still engaged in that area. I have already intimated to Mr. Mallet the necessity for greater activity in the field, for looking both to the nature of the work done, and of the country in which he was engaged I felt disappointed that a larger area had not been satisfactorily examined.

Carrying on the geological examination of the Gwalior and adjoining territories, Mr. Hackett was principally engaged near to the Byana hills bordering on Jeypur. The geology of this area has proved intricate and interesting. The sections are unfortunately not good, being cut up by intervening flats of alluvium which conceal the rocks. Rock masses of a peculiar character have been found to intervene between the Vindhyan series, and the metamorphic schists, which may approximately be taken to represent the Lower Vindhyan and the Gwalior series. These are possibly the same rocks as those which stretch away towards Ulwur, and if so, this will give a clue to the geology of the Aravali country. The country around Byana is, as I have already said, rather intricate in structure, and tedious therefore to work out, but I am not satisfied that a larger area might not have been completed during the season. Towards the close of the year, Mr. Hackett resumed his labours in the same or the adjoining country, but has been stopped by a want of maps. He has since been engaged further to the south in tracing out the boundary of the Vindhyan and trappean rocks to the east of the parallel of Neemuch, &c.

Mr. Hughes in the early part of the year was engaged in re-mapping the small coal-fields which occur detached near Kuroun in the district of Beerbhoom, and in revising with better maps, the Kurhurbaree coal-field. It has been difficult to obtain any very satisfactory information regarding this field, for the old pits which were some years since worked by the East Indian Railway Company are now full of water, and there are few other workings in operation. Any description, therefore, now given must be revised when the field is more opened out. At the close of the year, Mr. Hughes was engaged in the examination of the Palamow coal-field in Chota Nagpore. This might, Mr. Hughes thinks, be called in preference the Daltonunj field. It proves very small in area, not more than about 30 square miles, and there appear to be only two seams which can be worked, of which only one could at present be profitably extracted. This varies considerably in thickness. At Rajbera, where it was formerly worked by the Bengal Coal Company, it is eleven feet. It is of moderately good quality. The rocks of the field belong entirely to the Talcheer and the Barakar groups. The lithological character of the latter differs considerably from that of the typical rocks in the Ranigunj field, being as it were intermediate between the Barakar and the Ranigunj groups.

Mr. Ball has been carrying on the geological examination of the districts of Singhbhum and adjoining tributary states. He has been able to examine the copper-yielding rocks for a distance of nearly 80 miles; has noted some additional details with reference to the mode of occurrence of gold; and describes cases of excessive local metamorphism of the younger rocks, reducing them to such a crystalline condition as to be entirely undistinguishable lithologically from the old metamorphic rocks. Such cases are deserving of very careful examination.

Mr. Ormsby had, in the early part of the year, examined a considerable area of the metamorphic rocks in Chota Nagpore and Hazareebagh, but was unfortunately obliged to leave for Europe in consequence of ill-health before the close of the season.

Having very frequently had occasion to represent the importance of deputing a special officer of the Survey to the examination of the mines of India, and to the careful collection of statistics regarding the quantity and value of minerals raised and brought to market, I was glad to find that a gentleman, selected for this purpose, had been ordered to join the department at the beginning of the year. Mr. Mark Fryar, thus nominated as Mining Geologist in connection with the Geological Survey of India, joined his appointment in this country on the 1st of May 1868. After a little time in Calcutta, Mr. Fryar was deputed to the Ranigunj coal-field, there to make himself acquainted with the coal-bearing rocks of India, and the method of mining adopted in this, the most valuable, coal-field in India. It was necessary that he should acquire a knowledge of the rocks as locally developed, which would be useful in other localities, and indeed perfectly essential before he could safely take

up any enquiry in a new and undeveloped district. Mr. Fryar also, later in the season, visited the Kurhurbaree coal-field, when Mr. Theo. Hughes pointed out to him the several groups and their characteristic lithological characters. Towards the close of the year Mr. Fryar, was deputed to the Nerbudda valley, and to pass thence southward by Chindwarrā to Nagpore and Chanda, where Government had sanctioned the full and detailed examination by actual sinkings and borings of the extent and character of the coal known to exist there. For this purpose boring rods of best construction and borers have been despatched from England, and the work will be taken in hands at as early a date as possible. Mr. Fryar has submitted brief reports on the coal found at Lameta Ghāt, Jubbulpore, and on the workings at the Nerbudda Coal and Iron Co.'s colliery at Mopani. The localities must again be visited by some one knowing the Indian rocks.

I hope that the necessary appliances for boring, &c., which have been sent for, will reach this country before it be too late to do any thing this working season. Once commenced, the investigations will be carried on systematically, so as to ascertain exactly the full extent of area over which the coal beds extend and the thickness and nature of the coal itself. The country is much covered with alluvial deposits, and excepting by actual trials it will be impossible to say what the extent of the coal-fields may be, while the importance of the locality taken in connection with the supply of fuel on the Nagpore branch of the Great Indian Peninsula Railway and for other purposes, cannot be over-estimated.

It has not been found possible, with the reduced number of our staff, during the present season to place any one of the officers of the survey in this part of the country, with a view to trace out the extension of the coal-bearing rocks to the south from Chanda, if they do so extend. It is probable that the further extension will be traced, although the evidence seems tolerably conclusive that there is a continuous diminution in thickness of these rocks as they pass to the south; and it is highly probable that they will be found not to extend much further than they have been already traced. We know that they have entirely disappeared, at about seventy miles in that direction, and steps will be taken at the earliest possible date to have the intermediate country examined. Reports of the occurrence of coal have frequently been circulated, and recently it is stated to be in some quantity near Domagoodium: but these reports have not as yet been confirmed.

When proceeding to the Raniganj field, I specially directed Mr. Fryar's attention to the very high importance of inducing, if possible, the colliery proprietors to economize the large amount of waste and dust coal which at present is allowed to take fire and burn away to no useful purpose at the pits. The peculiar structure of Indian coal renders the proportion of this waste, produced in hewing, larger than in coal of a more homogeneous and richer character, while the very much greater brittleness of the strings of rich jetty coal as compared with that of the tougher laminae of earthy matter also adds to the proportion of the better fuel, which is lost in the waste. I urged on Mr. Fryar to induce some of the proprietors to make trial of washing and compressing this waste and dust so as to form bricks or cakes of fuel, and mentioned to him the success which had attended some experiments made by myself, on the use of common rice water as a medium for agglutinating the mass. Several trials were made and many bricks produced from washed waste, and, as I believe, good promise of success was established. The system has not, however, as yet recommended itself to the proprietors: they believe that the expense and cost would not be repaid by the result, and they have therefore not taken any steps to carry the trials further.

In the experiments I had myself made years since, and in those which were made by Mr. Fryar during the past year, no sufficient pressure was available. And in consequence, although the rice-water appeared to act very successfully, there was much too large a quantity of it taken up. The result of this was the comparatively open and uncompressed texture of the bricks, and when put on the fire they smouldered away rather than burnt. The only pressure used was that of a very inferior brick machine, nor was anything like proper attention paid to washing the dust before moulding.

I am quite confident that a very large amount of most valuable fuel could be with profit economized in this field, all, or almost all, of which is at present allowed entirely to go to waste. I do not anticipate that it will ever be profitable, under the peculiar circumstances of Indian fields, to adopt the suggestions thrown out by some who have never seen these fields, of reducing all the coal extracted to fine powder by crushing, then washing, moulding

and baking into symmetrical blocks. But I am satisfied that much may be made out of the dust and dead-small coal, now wasted. The peculiar conditions of the field render it compulsory that all this should be brought to bank so that the only expenses to be incurred are in the actual manufacture. It would surely be more profitable to reduce a larger portion of this waste into the state of good useful fuel than to allow it to take fire and burn itself to a heap of ashes.

Mr. Fryar's attention was also given to the utilization of the small coal and dust for the production of coke, and with considerable success.

During the past year, a circular was addressed to the proprietors of collieries from this office, urging on their consideration the vast importance of maintaining proper under-ground plans, pointing out very briefly the advantages to be derived from such. And I was much gratified to find from the replies received from every one of the large proprietors that they not only saw the advantages to be gained, but were determined to secure them. Careful plans are now being made of most of the mines in the Ranigunj field; plans of the workings in the Kurhurbaree field will be commenced as soon as the workings there commence under the East Indian Railway Company, and will be maintained. In the Nerbudda plans are kept. I look upon this as a most gratifying progress for a year or two. The largest coal proprietors in the Ranigunj field have not only engaged a qualified mining surveyor, but they have ordered all their assistants to pass an examination in the use of the surveying compass, &c., and have secured attention to this study by giving an increase of Rs. 50 per month to the salaries of those who may pass. The same Company has also given an excellent example of progress by ordering one of their own servants, and who, by their permission only, is also examiner of steam-ship boilers under the Government of Bengal (Mr. Walker), to proceed each half-year to their works to examine carefully and report upon, in detail, the condition, work, duty, and capabilities of every one of their steam engines; this report to be submitted previously to each half-yearly meeting of the Company.

MADRAS.—In Madras Presidency, Mr. Foote was absent on medical certificate during the greater part of the year. He only returned late in October. The remainder of the party, Mr. C. Oldham and Mr. King, commenced the season's work north of Ghootty, and marching up to Kurnool, surveyed, as they passed along, a sufficient breadth of country outside of the boundary line of the Kuddapah rocks, to ascertain the non-existence of any outliers of those rocks in that neighbourhood, and to obtain a good general idea of the character of that area of metamorphic rocks. It proved to be chiefly an area of granitoid gneiss, with a few trap-dykes, and some runs of fault-breccia; the prevalent directions of these being west-north-west, with variation to north-west, and east-north-east, with a variation to north-east.

From Kurnool, the Surveyors passed across the hills to the east, by the Muntaval pass. Mr. King separated from Mr. Oldham at Doopand, from which he moved northwards, carrying on his examination in connection with the survey of the previous season. Mr. Oldham proceeded to the Kistna district to join the Superintendent.

Mr. King rejoined Mr. Oldham in the middle of February, and working first through the Vinuconda taluq, they then passed into the Palnad, and carried their geological lines up to the Kistna River. Parts of this country are very difficult of access, wide areas quite uninhabited, without roads and without any means of obtaining useful supplies. Much of the geological structure is also intricate, and the district is at the same time very unhealthy. The temperature during the past year was unusually high in April and May, and repeated attacks of fever prevented the officers of the survey from carrying on their examination with their usual vigour. They continued, however, at work until the beginning of June, when Mr. King was compelled to proceed to station. Mr. Oldham went northwards and crossed the Kistna, hoping to be able to complete a detailed survey of the Juggiappett country. A part of this only could be accomplished, for the early and heavy break of the monsoon compelled him also to leave the field about the middle of June.

During the autumn Mr. Oldham delivered at the Civil Engineering College in Madras a course of lectures on Geology. These were attended, and with marked regularity, by a larger number of the general public than on previous occasions, while the engineering class was also very attentive and interested in the subject.

When I left the neighbourhood of Juggiapett early in the year, as already referred to, I had hoped that there would have been time to accomplish a detailed survey of that small area, taken in connexion with the adjoining country, before the close of the season. As I have just stated, the early and very severe setting in of the monsoon prevented this. I regret this the more, from the reiterated statements which have been made as to the existence of coal in that vicinity. Mr. C. Oldham, in regretting that he was compelled to give up the attempt to finish the work at that time, says—"I was, however, able to trace out the succession of the beds there for a considerable distance, and I had the opportunity of examining with somewhat more detail than we were able to do, during our visit early in the year, the way in which the rocks lie, and to convince myself (in entire accordance with your own conclusions) that, certainly over the part of the area which I was able to survey, in which are some of the localities where coal had been reported, not only does none appear, but that the occurrence of any thing like a workable seam of coal, unseen, is impossible. The rocks are singularly well exposed and their succession very clearly seen. The general succession of rocks seen in the Juggiapett area is, in ascending order, quartzite slate, limestone, schistose slates, and over these upper slates, in the hills to the south, comes apparently another set of quartzites.' The two lower groups, Mr. C. Oldham is inclined to refer to the Kuddapah series of rocks; and the limestone with the slates above it to the newer Kurnool group. There is apparently unconformity between the two series here, as in many other places. The Kurnool rocks cover a large area in the Palnad, and the two limestones with associated shales, are seen separated by quartzite, (the 'Panem' quartzite of the survey); this is locally of considerable thickness and forms a very well marked bed, but elsewhere it thins out to a couple of feet or even disappears altogether. The lower limestone of the Palnad is apparently identical with that which covers so very large an area near Juggiapett, although the actual continuity of the two still remains to be traced. Much of the limestone would form a very durable and excellent building material, and several of the beds would yield a handsome ornamental marble, being veined in different colours, chiefly buff and pink.

Chipped stone implements were traced up to the Kistna district. On the Muntaval pass, one was extracted from hard solid laterite.

From Bezwara, Mr. C. Oldham visited a small area of sandstone at Tunglamoody, about 14 miles south-south-east of Bezwara. These sandstones there form a rising ground or hill-lock of no great extent. They are quarried for use in the adjacent country, where many temples have been built of them. No fossils were traceable, but from the general character of the rocks, Mr. Oldham considers them as belonging to the same group as the plant sandstones further to the south, to some of which they bear a great resemblance. Further, while marching back to Madras from Gunttoor, he noticed similar sandstones, and some porcellanous shales in several places near Yinkolu, and south of that along the road: and at Razpoody a considerable amount of them is exposed, chiefly a greyish and yellowish shaly sandstone. These beds are quarried to some extent for local building purposes. The great resemblance lithologically of these rocks (shaly sandstones, and porcelain-like shales) to those in the neighbourhood of Sripermatoor, in the Madras district, is striking. Mr. C. Oldham thinks all these belong to the same series, and thus we have, at a distance of 450 miles from where we first found them in the Trichinopoly district, remains of a series of deposits once continuous, and the connection of which is now only indicated by the many detached areas of the same beds, which have been traced by the survey in the South Arcot, North Arcot, Madras, and Nellore districts.

BOMBAY.—The Bombay party of the survey has been during the whole year under the charge of Mr. A. B. Wynne, Mr. Blanford being, during all the time, absent with the Abyssinian Field-force. The party was engaged in the examination of Cutch, of which area about one-half has been very carefully completed. The reported occurrence of coal, said to be in workable quantity, was one reason which demanded a careful investigation of the rocks and their relations. But the principal interest connected with the investigation of Cutch centered in the fossils, which occur there in considerable abundance. Along with others, very well preserved remains of peculiar plants occurred, easily recognizable, and giving a very marked *facies* to the flora of these rocks. This was characterized by the predominance of various forms of Cycads. These same forms of Cycads had been found in abundance in Bengal, at the opposite side of the Indian peninsula, and in many places near to Madras, far to the south. In the Rajmahal Hills no associated beds occur from which the true geological horizon

of these plant-bearing rocks could be made out, while in Madras presidency also, although the succession clearly established that these rocks were not younger than the cretaceous formation there developed, there was (equally as in Bengal) no possibility of fixing their lower limit in geological time. In Cutch these plant-bearing beds, on the contrary, were said to occur associated with rocks rich in marine fossils, well preserved, and the geological epoch of which was well marked and readily determinable. But although undoubtedly associated with the marine fossiliferous beds, the mode of this association was still uncertain. Captain Grant, the original describer of the province, left it doubtful; while Mr. W. Blanford, during a cursory visit to part of Cutch, was led to believe that the plant-bearing rocks were actually intercalated with the others. The facts, as resulting from Mr. Wynne's very careful and detailed examination, appear to be that a very few and very imperfect remains of plants do occur in layers distinctly intercalated with the truly marine beds, and have probably been drifted into these localities from shores adjoining the seas in which the mollusca, now found fossilized in these beds, then existed. But as a whole the beds in which the well-marked *Palaeozamiae* occur are decidedly younger than those containing the truly Jurassic *Ammonites* and other characteristic fossils; and that they constitute an upper zone, but belonging to the Jurassic period. These very important results will be illustrated in detail in Mr. Wynne's reports.

Mr. Fedden has been engaged with Mr. Wynne in this careful examination of Cutch, and has more especially devoted himself to the portion of the province occupied by the tertiary rocks.

Very extensive and valuable collections of fossils have been made by this party of the survey, and transmitted to the Museum.

BURMAH.—Mr. W. Theobald, Junr., having returned from absence of leave, resumed the examination of British Burmah towards the close of the year. The time which elapsed up to the end of the year has been too brief to admit of any great progress. The country under examination has been that portion of the Prome district which stretches between the Eastern or Pegu Yoma and the Irrawaddi, and lies to the north of the Toung Raweng stream. This will, when finished, complete the whole of the Prome district east of the Irrawaddi. I confidently hope that we shall now be able to complete the examination of all British Burmah soon. The results at best are unsatisfactory from the absence of any good sections; and any attempt at classification of the rocks can only be of the largest kind. The whole country is too much covered to admit of any great detail.

PUBLICATIONS.—During the year under report, we have commenced the issue at stated intervals of a new series of publications called the "RECORDS OF THE GEOLOGICAL SURVEY OF INDIA." These are printed in smaller type and on thinner paper (for free transmission by post) than the more detailed Memoirs, but of the same size, so that they can on completion of a volume be bound with these. It is contemplated to issue a number every three months, making four numbers or parts in the year. It was impossible, however, to commence the issue until after several months of last year had passed, and therefore, for 1868, only three numbers appeared. In explanation of the object with which this series has been commenced, I may quote here from the brief Prefatory Notice which accompanied the first part. "This series will contain a notice of the current work of the survey up to date; a list of contributions to the Museum or Library; a list, and occasionally an analysis, of such books published elsewhere, as bear upon Indian Geology; and, generally, of all facts illustrating the immediate object of our researches, which may from time to time come to our knowledge."

The three numbers issued in 1868 have contained papers on very varied subjects; coal, gold, copper, fossils, and several local descriptive papers, which have proved of much interest to local officers; also lists of all additions to Library, &c., during the year.

I am happy to say this new series of publications, although necessarily issued with very few illustrations, has already attracted much interest, and I think will prove very useful.

Of the **MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA**, a very valuable part has been issued, containing a full report on the geology of the lower parts of the Nerbudda and Taptee Valleys by Mr. W. T. Blanford. The delay involved in the preparation of the necessary illustrations for this paper caused it to appear later than I had hoped. In the same part is also a detailed description of the structure and anatomy of the very curious little frogs long

known to be found in some thin papery shales near Bombay. To these Professor Owen had in 1847 given the name of *Rana pusilla*. More careful investigation, and more perfect specimens, show that these strange little frogs belonged to the existing genus *Oxyglossus*.

Mr. Blanford's report includes all the country lying between the parts already described by Mr. J. G. Medlicott (see Vol. II, *Memoirs Geol. Survey of India*) and the Gulf of Cambay, and thus completes a geological section right across the peninsula to the neighbourhood of Bombay.

This part completes Volume VI of the *MEMOIRS OF THE GEOLOGICAL SURVEY OF INDIA*.

Of the figures and descriptions of Indian fossils, included in the *Palaeontologia Indica*, the second half of the description of the Cretaceous Gastropoda was issued in October. This contained four fasciculi, and being ready at that time, I was enabled to issue it in advance, so as to carry the publication up to October of the present year. The danger of loss, the facility of destruction or injury, and the delay in transmission, of the smaller fasciculi, render it preferable to issue the whole series due for a year at once, if this be ready.

The description of the Gastropoda, concluded in these parts, was carried out to the close with the full detail to which I specially alluded in my last report.

Much progress has been made in the preparation of the needful plates for the illustration of the Bivalves, the group which will be published next.

At the request of several local officers we have, during the year, furnished brief geological descriptions of their districts, which they needed for statistical accounts, descriptive reports, &c., &c.

LIBRARY.—During the twelve months of 1868, we have added to our library 1,766 volumes, or parts of volumes, of books. Of this total 508 were presented or received in exchange for the publications of the Geological Survey from Societies and other institutions. We continue to maintain our catalogue of these books up to date, and in the new series of our quarterly publications (*THE RECORDS*) a complete list is given, in each part, of those received during the preceding three months. It is hoped that this announcement being sent to the several Societies from whom the presentations have been received will suffice as an acknowledgment, and will thus obviate the necessity of separate communications.

We are quite as seriously inconvenienced in our Library arrangements, by the want of sufficient space, as in the Museum. The books are necessarily placed in double rows and often far too crowded in their cases. This renders it impracticable to be as careful of them as might be, and also seriously interferes with facility of consultation or reference. To give fair room for all we would require at least double the number of cases and shelves we have at command.

To this report is appended as usual a list of the Societies and Public Institutions from which the Geological Survey of India has received donations or exchange of publications during the year 1868.

In my last report I stated that the literature of Geology, Mineralogy, Palaeontology, &c., had of late years so vastly increased that it was impossible to maintain our library effectively from the small sum annually appropriated to such purposes and I am happy to be able to state that an increase to this sum has since then been sanctioned.

MUSEUM.—Up to the close of the year we had not received all the series of fossils procured during 1867 in Europe, in connection with the purchase of the Klipstein collection. But few now remain to be received, and I hope to be in possession of all at an early date.

During the year, I had the advantage of the aid of Mr. Geoff. Nevill in arranging, preparing, and cataloguing these fossils as opportunity offered for opening and examining them. In many cases, the want of space has rendered it necessary merely to open, examine, check, and pack up again, box after box, as we have not space in which even to arrange, much less exhibit, our collections. Three additional rooms have been given up to the museum, and this will afford a certain amount of relief, when we have been able to procure cases. During the year more than 6,000 specimens have been catalogued.

We have returned to the Central Museum, Madras, the Cretaceous Gastropoda which they had been good enough to lend us for examination and description, and we have added to the

list as complete a series of duplicates of this group of fossils as our collections could afford. I think local museums should especially, and in preference to any more general illustrations, seek to render their collections specially rich and illustrative of local Natural History, and my desire has been to place in the Madras Museum the best series of duplicates which could be selected from the very interesting and valuable collections of Trichinopoly fossils made during our geological examination of that district in the Madras Presidency. With a similar object, I also sent to the Museum at Rajamundry as complete a series as our collections would afford of the interesting tertiary fossils found close to that town, carefully named, and with accurate references; so that those interested might have some good data for comparison, if they had the opportunity of adding to these local collections. We have also during the year examined and named for several persons specimens and small collections.

From the officers of the survey working in Cutch, the collections have received very large additions; among which are many good specimens. The other parties of the survey have not been engaged in richly fossiliferous districts. Mr. Medlicott has brought a small series from the Khasia Hills, and a few have been received from Burmah.

METEORITES.—To the noble collection of meteorites in our Museum have been added during 1868 specimens of the fall of Pultusk, 30th January, 1868: of Klein Menow, 7th of October, 1861: of Perth, 17th May, 1830; of Ornans (Doubs), 11th July, 1868; and of Lodran near Mooltan, 17th of October, 1868, being five in all. Of one of these (Klein Menow) our collection contained a minute fragment before, but we have now obtained a very splendid specimen. The others are all new to our series. For the very rare specimen from Perth, I am indebted to the friendly kindness of Mr. Wm. Nevill, Godalming, Surrey, from whom also I procured the Klein Menow specimen. To my good friend M. Jules Marcou, Paris, I owe the specimen of Ornans, while the contribution of that from Pultusk was among the latest communications received from the able Director of the Imperial Mineral Cabinet at Vienna, Dr. M. Hörnes, since deceased. This was only one among a very numerous and long-continued series of friendly communications, in which I have ever experienced the most hearty and graciously rendered support and co-operation from the Austrian Geologists, and from none more warmly than from the greatly regretted Hörnes.

A small map is as usual appended, showing roughly the areas of which the geological examination has been completed, or is now in progress, in connection with the survey.

THOMAS OLDHAM,

GEOLOGICAL SURVEY OFFICE; }
CALCUTTA, March 1869. }

Supdt. of Geological Survey of India, and
Director of Geological Museum, Calcutta.

List of Societies and other Public Institutions, &c., from which Publications have been received in donation or exchange for the Library of the Geological Survey of India during the year 1868.

LONDON.—Royal Society.

- ” Royal Institution.
- ” Royal Asiatic Society.
- ” Geological Society.
- ” Geological Survey of Great Britain and Ireland.
- ” Royal School of Mines.
- ” Royal Society of Arts.
- ” Royal Geographical Society.





DUBLIN.—Royal Society.
 ” Royal Geological Society.

EDINBURGH.—Royal Society.
 GLASGOW.—Geological Society.

CORNWALL.—Royal Geological Society.

VIENNA.—Kais. Hof Mineralien Kabinet.
 K. K. Geologischen Reichs-Anstalt.
 Kais. Akad. der Wissenschaften.

DRESDEN.—Naturwiss. Gesellschaft, Isis.

BERLIN.—Deutschen Geologischen Gesellschaft.

BRESLAU.—Schlesischen Gesellschaft für Vaterland. Kultur.

MUNICH.—Kön. Bayerischen Akad. der Wissensh.

MOSCOW.—Société Impériale des Naturalistes.

SWEDEN.—Bureau de la recherche Géologique.

NORWAY.—Royal University of Christiania.

PARIS.—Comm. des Annales des Mines.
 ” Société Géologique de France.

DIJON.—Acad. des Sciences.

CAEN.—Société Linnéenne de Normandie.

BELGIUM.—Academie Royale des Sciences, Bruxelles.

NEUCHATEL.—Société des Sciences Naturelles.

LAUSANNE.—Société Vaudoise des Sciences Naturelles.

ZURICH.—Naturforschenden Gesellschaft.

TUBIN.—Royal Academy.

GOETTINGEN.—Königl. Gesellschaft Wissenschaften.

GERMANY.—Leop. Carolino Acad. of Sciences.

COPENHAGEN.—Danish Academy.

PHILADELPHIA.—Franklin Institute.
 ” American Philosophical Society.
 ” Academy of Natural Sciences.

BOSTON.—Society of Natural History.

AMHERST, MASS.—Museum of Compar. Zoology.

SALEM.—Essex Institute.

WASHINGTON.—Smithsonian Institute.

NEW HAVEN.—Connecticut Acad. of Arts and Sciences.

TORONTO.—Canadian Institute.

VICTORIA.—Geological Survey.
 ” Office of Mines.

CALCUTTA.—Asiatic Society of Bengal.
 ” Agri-Horticultural Society.
 ” Indian Annals of Medical Science.

BOMBAY.—Branch of Royal Asiatic Society.

ROORKEE.—Thomason College of Civil Engineering.
 Governments of India, Madras, Bombay, Bengal, North-Western Provinces, Chief Commrs., Oude, Central Provinces, Burmah.
 Great Trigonometrical Survey of India.

NOTE ON PANGSHURA TECTA, AND TWO OTHER SPECIES OF CHELONIA, FROM THE NEWER TERTIARY DEPOSITS OF THE NERBUDDA VALLEY, BY FERD. STOLICZKA, PH. D., PALEONTOLOGIST, GEOLOGICAL SURVEY OF INDIA.

While engaged in the examination of the tertiary (? pleiocene) deposits of the valley of the Nerbudda river in 1858, Mr. W. Theobald, Junior, obtained, among other fossils, a few remains of CHELONIA which are of great interest as throwing light upon the then existing representatives of this reptilian order.

Mr. Theobald described these deposits at some length in a paper "On the tertiary and alluvial deposits of the central portion of the Nerbudda valley" (Memoirs, Geol. Surv., India, Vol. II, p. 279). He distinguishes two groups of beds, an upper and a lower. To both of these a large number of the fossils is common, but Mr. Theobald is inclined to think that those of the upper group may have been, partially at least, derived from the denudation of the lower group. The beds of this lower group are more fossiliferous than the others, but they can only be examined where they are exposed in the banks of the Nerbudda river itself, and in those of a few of the larger tributaries. The same author also gives a list of land and fresh-water shells found in these beds. Many of the species noted are still met with recent, and some appear to be identical with those determined by Prof. Ed. Forbes from the Sevalik strata (see Falconer's Paleont. Mem., Vol. I, p. 389). Of the vertebrate fossils also, several species are common to both the Nerbudda and Sevalik strata. Still some peculiarities in the Bovine and Pachyderm types have been pointed out, which seem to show that the deposits of the Nerbudda valley are younger than those of the Sevalik hills. On this point it is difficult to arrive at any definite conclusion from the examination of the fossils alone. The comparatively larger number of Bovines in the Nerbudda beds, as contrasted with the Pachyderms, the absence of Mastodons, &c., may be due to local causes. And further, the number of fossils as yet known from the Nerbudda is small, while from the Sevaliks, which have been examined more in detail, we have a large number of well determined species. The only question is, whether all the fossils which have been described from the Sevaliks really belong to one series of beds only, or whether they do not in reality represent somewhat distinct horizons (the Nahun series, the upper and lower Sevaliks, &c.). It is certain that no particular attention was paid to these divisions when the earlier collections were made. Much is therefore still left to be worked out, both in the Nerbudda and in the Sub-Himalayan country.

In the present note I shall direct attention only to the Chelonian remains from the Nerbudda valley. Mr. W. Theobald, in his report quoted above, repeatedly states that Chelonian remains occur throughout the lower group, but that they are rare as compared with those of the Mammalia (see pp. 289, 290, 292). Besides these remains of Chelonia I am not aware that any other reptilian remains have been met with in the Nerbudda beds, although Saurians and others most probably existed within that area, as they do now, and as they did already during the time, and in the area, of the Sevalik deposits.

These Chelonian remains are referrible to three species; one, which is sufficiently preserved, has been identified with the recent *Pangshura tecta*, and, of the three other fragments, one appears to belong to a recent *Batagur*, and the other two to a *Trionyx*.

I shall give first a short description of these remains, and then add a few words respecting the conclusions resulting from this examination.

PANGSHURA TECTA, BELL, SP., PLATE I, FIGS. 1, 2.

Emys tectum, Bell, Monog. Testudinorum.

" *tecta*, Gray, Illustrations of Indian Zoology.

" *Namadicus*, Theobald, 1860, Mem. Geol. Surv., India, Vol. II, p. 295.

Pangshura tecta, Günther, 1864, Reptiles of India, p. 33.

Emys tecta, Falconer's Pal. Memoirs, 1868, Vol. I, p. 388.

The shell of *Pangshura tecta** has an elongated oval form. The centre of the back is elevated, more or less distinctly carinate, the sides are rather flattened and slope at an angle of about 45°, which increase up to 50° towards both ends. The carapace is anteriorly

* I have adopted here the change in the specific name, *tecta*, as being more in accordance with the general system of nomenclature, although Bell said that Gray had misquoted the name *tecta* instead of *tectum*, the roof of a house, which was intended to express the general form.

about equal to, or a little shorter than, the sternum, and slightly emarginated; posteriorly it is obtusely rounded, and at the marginal shields more or less distinctly serrated.

In the specimen figured on Plate I,—which was discovered by Mr. W. Theobald at Moar Domar in the Nerbudda valley,—the carapace agrees in every respect with that of the recent species, as will be shown by giving the necessary details of its structure. To facilitate a careful comparison, I have also given a drawing of one-half of the dorsal and ventral views of the carapace of a small specimen, procured living in the neighbourhood of Calcutta. These drawings are intended to illustrate not only the epidermoid but also the osseous shields. Proper attention is seldom given to the latter in zoological works, although in paleontological researches they are of greater importance than the former.

The fossil figured is not perfect, the posterior portion of the carapace not having been found; but the rest of the shell is quite sufficiently preserved to admit of careful comparison for specific identification. The general form of this fossil is, as already stated, exactly the same as that of recent specimens.

Epidermoid plates.—The nuchal shield is very small, narrower anteriorly than posteriorly. All the five vertebrals are obtusely carinated in the middle, and the first three become successively more and more elevated at the posterior end. The first vertebral is pentagonal with an obtuse projecting angle in front, slightly emarginated at the sides, narrow and truncate behind. The second vertebral is about the same size as the first, also pentagonal, truncate at both ends, considerably narrower posteriorly than anteriorly, laterally, at one-third of the length from the front edge, widest and angular. The third vertebral is the smallest, but the highest of all, pentagonal, truncate in front, angular at the sides, after which considerably produced posteriorly, becoming gradually narrower and terminating with an obtuse point. The fourth vertebral is bell shaped, very much prolonged, joining the third with an obtuse point, then becoming gradually wider until it reaches about three-fifths of its length, after which it narrows again, terminating with a truncate side, about one-half of the greatest width of the shield. Of the fifth vertebral only the anterior portion is preserved, showing it to be truncate in front and quickly widening posteriorly. The sides were probably obtusely pointed and the posterior termination truncate, broader than the anterior, as in recent specimens. In these the sides of the fifth vertebral are sometimes pointed, sometimes distinctly truncated. Costal or lateral plates are five, all being transversally elongated and of a more or less irregular pentagonal shape. They entirely agree with those of living specimens, as is equally the case with the marginal shields, which are eleven in number on either side. The serration of the posterior marginal shields remains to be properly recorded if better preserved specimens should be discovered, for neither is it distinctly traceable in the figure given by Dr. Murchison in Falconer's Pal. Memoirs.

On the ventral side we have first to notice a pair of small, triangular, posteriorly pointed gular shields. To these follows a pair of larger, subquadangular post-gulars; then a pair of rather high pectorals, next to which are the abdominals, being the largest, and then the other shields of normal size. The axillaries are comparatively small, posteriorly pointed, the inguinal large anteriorly, on the external side obliquely truncate. The longitudinal ridge which connects each axillary with its corresponding inguinal is very distinct, sharp and slightly longer than in most recent specimens. The plastrum is distinctly concave, probably a little more so than in male specimens, as usually met with about Calcutta.

Osseous plates.—The distribution of the osseous plates, as is well known, does not agree with that of the epidermoid shields. There is a very large nuchal plate and a very small caudal, the latter not being preserved in our specimen. There are ten small vertebrals, the last (the largest) not being seen in the fossil, but the other nine perfectly agree in their relative proportions and in their relations to the epidermoid shield with those of live specimens. The costal shields are eight; the first is the broadest, with reference to the longitudinal diameter of the carapace; all the others are very narrow. The number of marginals is eleven on each side.

On the plastrum we have a pair of subquadangular gular shields, to which follows a pair of very large pectorals, these four shields enclosing in the middle a single, suboval post-gular; there is besides a pair of very large abdominals and one pair of smaller anals. The axials and inguinal are not separated from the pectorals and abdominals respectively.

No portions of the internal skeleton, as the extremities, &c., have been found preserved.

The epidermoid plates in *Pangsh. tecta*, and other allied species, are subject to a great deal of variation, which is especially considerable in the form of the vertebral plates, occasionally so much so that they cease to be of great specific importance. The most variable are the first and the fifth vertebral plates. In the Indian Museum there exists a remarkably large specimen of *Pangsh. tecta* from Cachar. Its first vertebral is pentagonal, the second quadrangular, third rather large, of regular form, fourth very large, bell shaped, the fifth is three-fifths of the length of the former, of almost equal width throughout, truncate in front, sub-angular laterally, and obliquely pointed posteriorly, while, as a rule, it is truncate behind (see fig. 2, pl. 1). There are twelve marginals on each side, instead of eleven, the tenth being divided by a furrow in continuation of the suture which separates the fifth costal from the fifth vertebral. The caudals are very small.

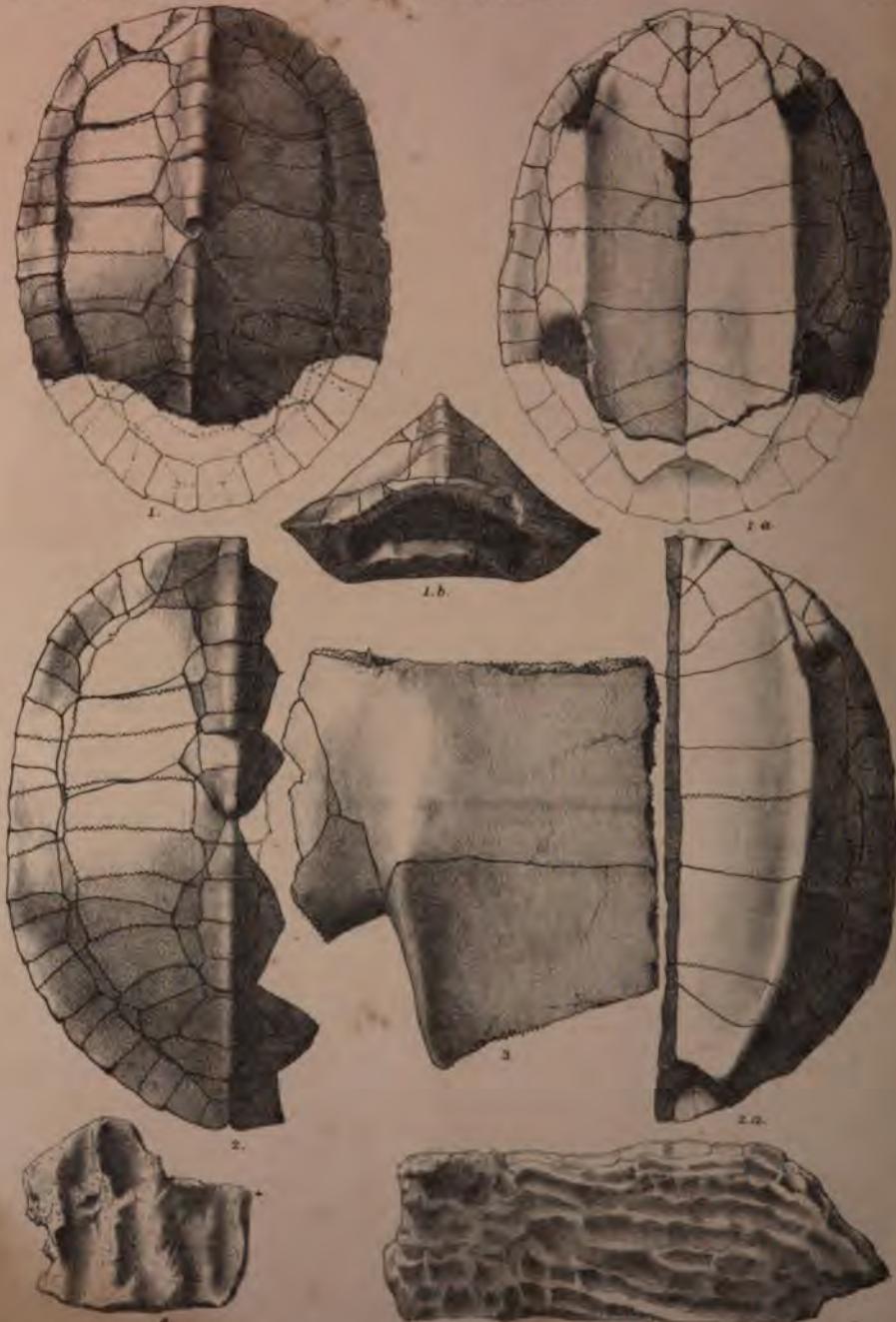
Comparing the epidermoid shields of some of the specimens of *P. tecta* with those of *Pangsh. tentoria*, it is by no means easy to point out any very remarkable distinctions, but the latter species can be always recognised by its broad, depressed back, the sides of the carapace being distinctly convex, and the general form of the shell more elongated. (See Theobald's Catalogue of Reptiles, etc., Jour. Asiat. Soc., Bengal, Extra No. 146, 1868, p. 14). Günther's figure of *Pangsh. tentoria* is by no means characteristic, being almost undistinguishable from that of *P. tecta*.

The costal shields are, on the contrary, much more constant, and they do not appear to vary essentially in allied species and genera. In all the species of *Pangshura* which I have examined they were arranged quite identically.

Mr. Theobald proposed for the specimen here figured the new specific name " *Namadicus*," while Dr. Falconer, in an essay already written in 1844 (see Falconer's Pal. Mem., Vol. I, 1868, p. 382), had identified another specimen found in the Sevalik strata with the recent species. The examination of the Nerbudda specimen has strongly confirmed Dr. Falconer's investigations; that celebrated naturalist summing up his results in the words, "that we are not justified in constituting a difference where we do not find it." Judging from all the solid parts of the carapace, it cannot, I think, be reasonably questioned that the Nerbudda and the Sevalik fossils, as described by Dr. Falconer, are both of the same species, and identical with recent specimens of that species. It might, of course, be said by some naturalists that the fossil specimens may have been, for instance, quite differently coloured, and this would be sufficient to constitute a specific distinction. Such hypotheses cannot, however, be admitted as having any value in pointing out specific distinctions of fossils.

I have no doubt that the specimen from which Dr. Falconer's description was taken is a true *Pangsh. tecta*, but it seems very doubtful that it was the identical specimen figured by Dr. Murchison on Plate 32 in Falconer's Pal. Mem., Vol. I. I have little doubt that this last one is also a *Pangsh. tecta*, but it can scarcely be the identical specimen which Dr. Falconer described. Dr. Murchison (in a note on page 382) pronounces the figured specimen to be the original of Dr. Falconer's description, but when writing the explanation to the plate some of the differences must have struck him, and here he leaves the identity of the specimen doubtful. On page 383 Dr. Falconer says, with reference to the first vertebral, (of the epidermoid coat), "the exact form is not distinctly seen, though it seems to converge less * * *." In the figure two-thirds of the first vertebral are broken off, and no convergence is perceptible. Farther, the author says, "the outline of the fourth scute is not distinguishable in the fossil, and the fifth one is wanting." In Dr. Murchison's figure the fifth shield appears perfectly preserved. With regard to the fourth vertebral scute there is an error in Dr. Murchison's figure. The draughtsman has in place of the outline of the epidermal shield marked the outlines of three osseous plates, and of these he does not seem to have given the outlines quite correctly. The fourth epidermoid vertebral scute extends over three complete osseous vertebrals and an additional one-half, or nearly that, on either end (see pl. I, fig. 2). It is important to point out this distinction, though every one, looking at Dr. Murchison's figure, will readily notice that some mistake of that kind must have occurred. For no *Emys* or *Pangshura* possesses seven scutes in the epidermoid covering, and if intended as a representation of osseous shields, the number is, as I have already stated, too small. In spite of this discrepancy and the somewhat strongly bi-tuberculated second vertebral scute, I can hardly think that the specimen figured by Dr. Murchison belongs to any other species than *Pangsh. tecta*.





BATAGUR SP., *conf. DHONGOKA*, Gray, Pl. I, Fig. 3.

Günther's Reptiles of India, Ray Soc., 1864, p. 42.

One right abdominal osseous shield has been found in the conglomeratic beds near the village Omeria. This abdominal osseous shield is 108 m.m. long and 94 m.m. broad in the region of the inguinal process. Its form, the flat surface and the outlines of the junction of the abdominal and pra-anal shields, of the inguinal and of the adjoining marginal on the external side, entirely agree with the form of the same shields of the recent *Batagur dhongoka*. Further materials are, however, necessary to show whether this supposed identification be correct.

The species occurs at present throughout India, especially in the larger rivers, and it is found up to the present time in the Nerbudda. Judging from the size of the fossil shield, the specimen to which it belonged must have been about one foot long; specimens much larger than this are met with alive now in India.

TRIONYX SP., *conf. GANGETICUS*, Cuvier, Pl. 1, Figs. 4—5.

Günther's Reptiles of India, Ray Soc., 1864, p. 47.

The two fragments which are referrible to the above species consist of the largest portion of the left lower inguinal plate, and a fragment of one of the bony (sternal) processes with broad longitudinal furrows. The rugose surface of the inguinal plate entirely agrees with that of *Trionyx gangeticus*, and this is the only reason which can at present be brought in support of the presumed identification of the fossil with the recent form. The thickness of the plate shows it to have belonged to a large specimen. These two fragments were also met with in the conglomeratic bed near Omeria. *Trionyx gangeticus* is found at the present time living in most of the large Indian rivers, especially in the Ganges and its tributaries.

We have thus up to the present three species of Chelonia upon record from the newer tertiary fluviatile deposits of the Nerbudda valley. These all belong to forms which live in fresh water, and so far agree with Mr. Theobald's conclusions, derived chiefly from a consideration of the shell-fauna, that there are no traces of any estuary or brackish-water deposits. Of these three Chelonia we may accept with the highest probability the identity of *Pangshura tecta* with the existing species, and the great similarity of the other two to existing species is also unquestionable. The Chelonia, probably unnoticed by man, appear to have changed far less in the lapse of time than the Mammalia. The *Pangshura tecta*, and probably two other species (not yet known to occur in the Sevaliks proper), have then continued to exist unaltered, from the time of the *Sivatherium*, *Mastodon*, various *Elephants*, *Hippopotamus*, *Colossochelys* and others, down to the present time. The changes in the conditions of climate, &c., may not have been great, and if the species of reptiles survived these changes man surely would have been able to do the same, had he existed at that early date. That he did so exist, and that he was a contemporary of the *Colossochelys*, as Dr. H. Falconer suggested long since, we have no reason to doubt, although as yet we may not be able to adduce any direct proof of the fact.

EXPLANATION OF PLATE I.

Figs. 1, 1a, 1b; dorsal, ventral and front views—half the natural size—of the carapace of a fossil specimen of *Pangsh. tecta* from newer tertiary conglomeratic beds near the village Moar Domar in the Nerbudda valley.

Figs. 2 & 2a; dorsal and ventral views of half the carapace of a recent specimen of the same species; (natural size).

Fig. 3 ... Ventral view of a right abdominal osseous shield of a species closely allied to, or identical with, *Batagur dhongoka*, Gray, from the same beds as Fig. 1; (half of natural size).

Fig. 4 ... Portion of the sternal process of a species closely allied to, or identical with, *Trionyx gangeticus*, from the same beds as the last; (half of natural size).

Fig. 5 ... View of a fragment of the inguinal plate of the same species as the last, and from the same locality; (natural size).

SKETCH OF THE METAMORPHIC ROCKS OF BENGAL, BY H. B. MEDLICOTT, A. B., F. G. S.,
Depy. Supt., Geol. Survey of India.

From the descriptions of the earliest geological observers in India it has been known that large areas are occupied by metamorphic and submetamorphic rocks. It might not appear from its publications that the Geological Survey had given to these formations their due share of attention. But such an inference would be far from correct: coloured maps of large districts might long since have been published, with a general description of the lithology and of the superficial stratigraphical features; and specious analogies might have been drawn with the 'fundamental' rocks of other countries; but any such accounts would be illusive without some definite judgment upon the structure and relations of the several rock-groups. The following notice is a brief abstract of observations made by me during two seasons (1862-63, 1863-64) spent on these rocks, from the watershed of the peninsula near Jubbulpur, in an east-north-east direction, to Monghyr on the Ganges, a direct distance of more than 400 miles. Those who have any knowledge of the difficulties attending the investigation of such rocks will at once understand that my explanations can be only tentative.

The broad promontory round which the Ganges turns at Rajmahal is the termination of a great expanse of gneissic rocks. Here, throughout its eastern extremity, for nearly 100 miles, the gneiss is covered and bounded by the Rajmahal Trap, with its associated plant beds (jurassic), locally underlaid by other members of our Indian Stratified Series; and various outliers, of irregular shape and size, of these latter deposits, comprising our best known coal-fields, are scattered over the area to the west; but from the Rajmahal boundary the gneiss is continuous for 400 miles to the west-south-west to where it passes under the Great Deccan Trap (*supra cretaceous*) of the Mundla plateau. From the south extremity of the Rajmahal Trap the general boundary of the metamorphic area extends to the south-south-west. Across the middle of the area a straight line might be drawn for more than 150 miles from north to south, continuously on crystalline rocks.

Throughout the greater portion of the northern boundary (the region to which my observations more especially refer), and with few exceptions wherever rock is more exposed, the gneiss is in contact with submetamorphic rocks—slates, schists and quartzites. The exceptions are where, only very locally, the Lower Vindhyan lap on to the gneiss, and where the crystalline rocks themselves extend through and beyond the otherwise regular and continuous run of the schists. This latter case is a most important one; it occurs in about the middle of the region, and is connected with an interruption of nearly 80 miles in the run of the schists, dividing them into two separate areas, and introducing all the doubts and difficulties of identification. In the western area the submetamorphics are continuous along the south side of the Sone valley and into the Nerbudda valley, and are throughout the whole extent bounded on the north by the great Vindhyan range, the strata of which rest totally unconformably upon the schists. In the eastern area, in Behar, the slate series appears in detached groups of hills more or less isolated in the deposits of the Gangetic plain; the principal of these hills are those of Rajgir, Kurrukpur, Ghiddour, Bheowa, and Mahabur. There is perhaps a presumption that the analogous rocks in the two divisions of this great zone are closely related, but many circumstances combine to complicate the question of identification: in the western area the rocks are principally argillaceous, and the metamorphic products of such; while in the east, quartzose deposits largely predominate. Again, this break of continuity is coincident with the eastern extremity of the immense spread of the Vindhyan rocks, and thus, through a general analogy of composition, the possibility was at first suggested (the crystalline rocks not being necessarily all of one period) that the quartzites of Rajgir, &c., might be altered Vindhyan. This supposition may, I think, be quite set aside: the Lower Vindhyan near their eastern limit rest quite unaffected upon the granitics; and the most peculiar and characteristic beds of the Lower Vindhyan series are most extensively developed in this position, yet there are no rocks among the submetamorphics of Rajgir that would even approximately represent them specifically. There is, on the other hand, no inherent difficulty to the general equivalence of the submetamorphic series in the two regions, in the fact of there being much difference of composition at so considerable a distance. It need hardly be stated that only the leading relations of the rocks are to be noticed: no fossils have as yet been discovered in any of them, and no detailed work has as yet been attempted.

The superficial relation of position—a great spread of crystalline, fringed by sub-metamorphic rocks—is already variously suggestive: the rival leading questions would be—to what extent are the crystallines granitic and intrusive, thus determining the present limit of the schists? or, if the crystallines are in the main gneissic and themselves metamorphic, how far may the present limitation of the submetamorphic series as a fringing deposit be an original feature? No satisfactorily one-sided answer can be given: the facies of the crystalline rocks is emphatically gneissic (metamorphic); there is also ample evidence of granitic intrusion in the rocks of both series; yet, owing to theoretical scruples, and to deficiency of data, the residual phenomena are so numerous that no approximately final judgment can be put forward even as to the main relative ages. It is time, however, that our difficulties should be ventilated. The lie of this great band of slaty rocks, on the south of the Gangetic valley, and followed up, as it is, by the next succeeding deposits of the Vindhyan series, suggests at first sight inferences as to the possible substratum of the great alluvial formation, as to the inducing conditions for the great area of erosion or of depression, and as to possible relations to the rocks on the north of the plains, in the Himalayan region. But, whatever independent interest these large structural features may retain, such speculations as those mentioned are in a great measure negatived by the appearance to the north of the Vindhyan in Bundelkund of a large area of thorough gneissic rocks; and again, in Behar, in the small group of the Barabar hills, well to the north of the Rajgir range, we find very massive gneiss of most ancient aspect.

I must here briefly recall to notice some observations I made in 1856-57 in a neighbouring part of India (published in the 2nd Vol. of our Memoirs) as bearing upon the question before us. To the north-west of the Sone valley, and separated from it by the long eastern prolongation of the Vindhyan formation, there is the large area of crystalline rocks of Bundelkund; it is bounded on three sides by the Vindhyan and on the fourth by the Gangetic plains. Along the south-east border of that area there appears a strip of semimetamorphic rocks—quartzites, limestone* and slaty strata, with contemporaneous trap, rising from beneath the Vindhyan. I described them as the Bijawur formation. They are in many places seen to rest abruptly upon a flatly denuded surface of the gneiss of that area. The bottom rocks in this position are peculiar quartzites, often compact and brecciated, and massive cherty limestone; but along portions of the boundary the usual Bijawur strata are underlaid, with at least approximate parallelism, by very non-descript gneissoid strata. The demarcation between these and the true gneiss is, naturally, very obscure; and it was not then possible to work it out; but there are locally some intercalated beds of quartzite-sandstone that effectually betray the stratigraphical affinities of these indeterminate strata to be towards the Bijawur rocks, and totally distinct from the true gneiss, to which they seem in the relation of an ancient superficial covering. We shall see that probable representatives of the Bijawur rocks occur both in the Sone valley and in Behar; and that thus we may at least get a hint as to the relative ages of the gneiss of the two areas.

A large part of the submetamorphic area of the Sone valley is occupied by rocks that would well represent the Bijawur—ferruginous slaty schist with quartzite, limestone, and much contemporaneous trap. They are much more disturbed than in Bijawur; it is even probable that they are affected by certain granitic intrusions. The uncertainty upon this and upon other unsettled points regarding their relation to the main crystalline area to the south is largely owing to the presence of another older series of slaty rocks in the Sone area. The Bijawur deposits are known to be somewhat fickle, but unless they are so beyond all possible conjecture, there can be little doubt of the existence of this older series. In some of the best sections, notably in that of the Rehund, there is a clear transition from the coarse felspathic gneiss, through well marked stages of crystalline metamorphism, into a series of fine clay-slates, with plenty of intrusive greenstone, but in which none of the characteristic Bijawur rocks can be recognised. Where decided Bijawur rocks come in contact with the gneiss there is no such intimate relation between the two. Now that maps of this ground are available there is some prospect of our being able to unravel these obscure questions.

The hills formed of the submetamorphic rocks in Behar appear generally as precipitous ridges of quartzite, either singly or massed together in groups. Even in the

* The limestone of Dergoan, which I had doubtfully described as an outlier of the Lower Vindhyan limestone, has since been shown by Mr. F. R. Mallet to belong to the Bijawur series.

them and the Bheowa ridge; here also the general appearance is similar to that of the other principal hill groups.

Upon these general considerations of similarity of structure, position, and to a great extent of composition, one would not hesitate to suppose the rocks of all these eastern groups to belong to the same formation as the Rajgirs &c.; it is the conflicting evidence of the bottom-rocks, as already noticed, that would suggest a doubt—in the best sections I have seen at the base of the Kurruckpur and Ghiddour hills, the rocks near the great quartzites resemble those of Luckieserai. Although it would still be possible that there are two series of equal magnitude, and so closely resembling, yet quite distinct, the presumable unlikeness of such being the case would quite outweigh all the difficulties to their complete identification; and it is only on the supposition of the sections to which I allude proving deceptive that I would venture to suppose there being any separation at all among these rocks, further than what may exist between the groups described in Bijawur to which I would then consider them parallel. The case I would explain is well exhibited at the east end of the Ghiddour range: for some distance a low flanking ridge follows the curve, and close to the base, of the great cliff of quartzite; it is principally formed of a coarse schist-conglomerate, sub-angular pieces (some are six inches across) of quartzites undistinguishable from those of the cliff, even to the peculiar innate mica; still the rock is thoroughly metamorphic, with the pebbles firmly soldered to the matrix. The underlie of this rock here is 30° to 50° westwards, thus apparently underlying the rocks of the range above. At the south-east angle, however, instead of following the run of the range westwards, it trends away to south and south-east, with very low dips, and completely identifies itself with the similarly arranged gneiss, schist and subordinate quartzite that cover so much of the low ground. I have little doubt in identifying these rocks with those at Luckieserai; and it appears to me more than doubtful that they truly underlie the Ghiddour quartzites. There is ample evidence on record of younger, apparently passing under older, deposits; and without involving the inversion of either. On the strength of their much more advanced type of metamorphism, these gneissic rocks at the base of the Kurruckpur and Ghiddour ranges have been considered altogether more ancient than the rocks of the hills; but if the suggestion now made be confirmed, that order will have to be completely reversed.

The same conjecture occurred to me from an independent point of view in the neighbourhood of Mahabur. Within about a mile of the east end of this ridge, right in the axis of its strike, we find these associated layers of tough mica-schist, hornblende-schist, gneiss, and subordinate quartzite, covering considerable areas at low undulating angles of disturbance. I was quite unable to conceive how such rocks could have been where they are at the time when the great quartzites were so intensely plicated, and the schists below them received their steady cleavage. The foliation of the Mahabur schists is cleavage-foliation; that of those other rocks is strictly lamination-foliation. This mechanical objection is at least as valid as the chemical one to which it is opposed, and which would determine the relative ages by relative metamorphism. But, indeed, there is little to choose between on this score here, for the Mahabur schists are often gneissose, containing much felspar.

In connection with this question of relative ages, it is necessary to notice the structure of the ranges as related to their distribution. Their isolated positions are not simply due to denudation: it is certain that the matter removed from between them at their present common level consisted in great part of crystalline rock. Uniform as is the general strike of the ridges, the termination of the ranges does not present a serrated front; the quartzites of the outer longitudinal ridges are bent round in a sharp regular curve, forming a continuous ridge of equal or greater elevation at the curve, with a precipitous external face, and generally an equally regular converging internal underlie. This feature is more especially well marked on the eastern aspect. In the larger groups there are internal features of the same kind; the contortion presenting a two-fold system of corrugation, one of which (the east-west one) greatly predominates, producing the marked longitudinal outline of the ranges. The cleavage and its foliation in the schists have been observed to follow these same curves. It was partly upon this evidence in the Rajgir group—that one can walk from any one ridge to any other without crossing a band of the schists which appear so freely in the enclosed valleys—that I inferred the supraposition of the quartzites. The drainage of these internal valleys does not take place endways, but by narrow gaps cut through the longitudinal ridges of quartzite. Outside the hills granitic rocks are sometimes seen in front of these abrupt terminations of the quartzite ranges. Thus it would seem as if the existing masses of the sub-metamorphic rocks had occupied areas of locally greater

depression at the time of the first great granitic invasion; and that to this we may owe their ultimate preservation as hill ranges. The feature is well exhibited in Mahabur: the axis of the range would strike up a reach of the Sukri, and on each side of the river there is an elongated oval of granitoid rock, as of denuded domes. The characteristic arrangement of the doubtful gneissic rocks is also better shown here than anywhere I could mention: they appear as regular concentric coatings to the granitoid masses. The area on the south is less elevated, and the diverging dips of the covering rocks range from 5° to 20° ; on the northern area they are much steeper as if exposed lower down on the sides of the mass they envelope, but the regularity of the encircling ring is unbroken, and of the same description of rock as on the south, but in thicker masses. Upon the usual evidence of regularly alternating stratification of highly contrasting materials, it is not, I presume, to be questioned that these are true detrital accumulations remineralized; and it might, I suppose, be maintained on the strength of some misunderstood process of hypogene intrusive action that they may have underlaid the Rajgir formation; or it might even be said that the stratigraphical features of the Mahabur region suggest such a relation. But from the evidence before us, I confess to a preference for the contrary supposition: it would require that after the great disturbance and metamorphism of the Rajgir series the whole area was denuded to a much greater extent than now, and that upon the surface thus exposed these accumulations took place, probably of some arkose-like materials, very susceptible to mineral reorganization. Such must have been the composition of the bottom-infra-Bijawurs.* In this Behar area, however, there is ample evidence of a later granitic invasion: in the southern tributaries of the Sukri there are fine sections of great granite dykes traversing all the rocks transversely. This granite is very different from that already noticed; it is highly crystalline; in the centre of the dyke the felspar and quartz form a coarse graphic granite, with associated schorl and beautifully plumose mica. The view I have proposed would imply a prodigious relative antiquity for the Rajgir formation.

The views that have now been presented in connection with the submetamorphic series have manifestly very direct bearing upon the rocks of the great gneissic area. Supposing the conjecture regarding the extensive representation of the peculiar infra-Bijawurs to be correct, there would be four principal geological divisions to be discriminated and mapped, exclusive of all later granites, &c. 1st. There would be the gneissoid granite, which would seem to be largely present, to be distinguished from true metamorphic gneiss. I should despair of settling this point without the extensive application of microscopical analysis of the rocks; indeed it remains to be seen whether even this test would furnish a criterion, whether the crystals of such a rock would not assimilate more to metamorphic than to fully igneous products. 2nd. It is more than probable that associated with that granite we should find a most ancient gneissic formation long anterior to the metamorphism of the Rajgirs, and possibly equivalent to the gneiss of Bundelkund. 3rd. We should probably find remnants of the Rajgirs in their gneissose form. On this point there is some information at hand: far within the great crystalline area, near the Grand Trunk Road north of Burhi, there is an inlier of typical Mahabur (Rajgir) schists. If they always remain so characteristic there will be no difficulty in recognising them. Even here they are attended by the encircling ring of variable quartzites, having high converging dips towards the schists, which occupy the lowest ground in the neighbourhood on the banks of the Barrakar. The quartzites form a narrow ridge round them, and would belong to our next division. 4th. There would be the hypothetical infra-Bijawurs. The establishment of this series would probably relieve our field work of some perpetually outcropping difficulties, especially in the shape of isolated, discontinuous runs of quartzites and breccias. But apart from these more characteristic beds, I could not now assign a lithological criterion for this series generally: as has been seen they even simulate granitic masses. Great irregularity and discontinuity is one of their features; although frequently presenting excessive contortion, as if when caught between two resisting masses, they are generally comparatively little disturbed; and what disturbance they exhibit seems to be largely determined in direction by local circumstances, resulting in great irregularities of dip. In Bundelkund, where they were first detected, these beds seem to have but little extension; but in Bengal they seem to occupy large areas: I have observed rocks of this description in far distant localities of the great gneissic area.

January 1869.

* As a more recent parallel for such kind of deposits, I would refer to the felspathic beds of the lower Vindhya as exposed in western Behar, to south-west of Kutumbeh.

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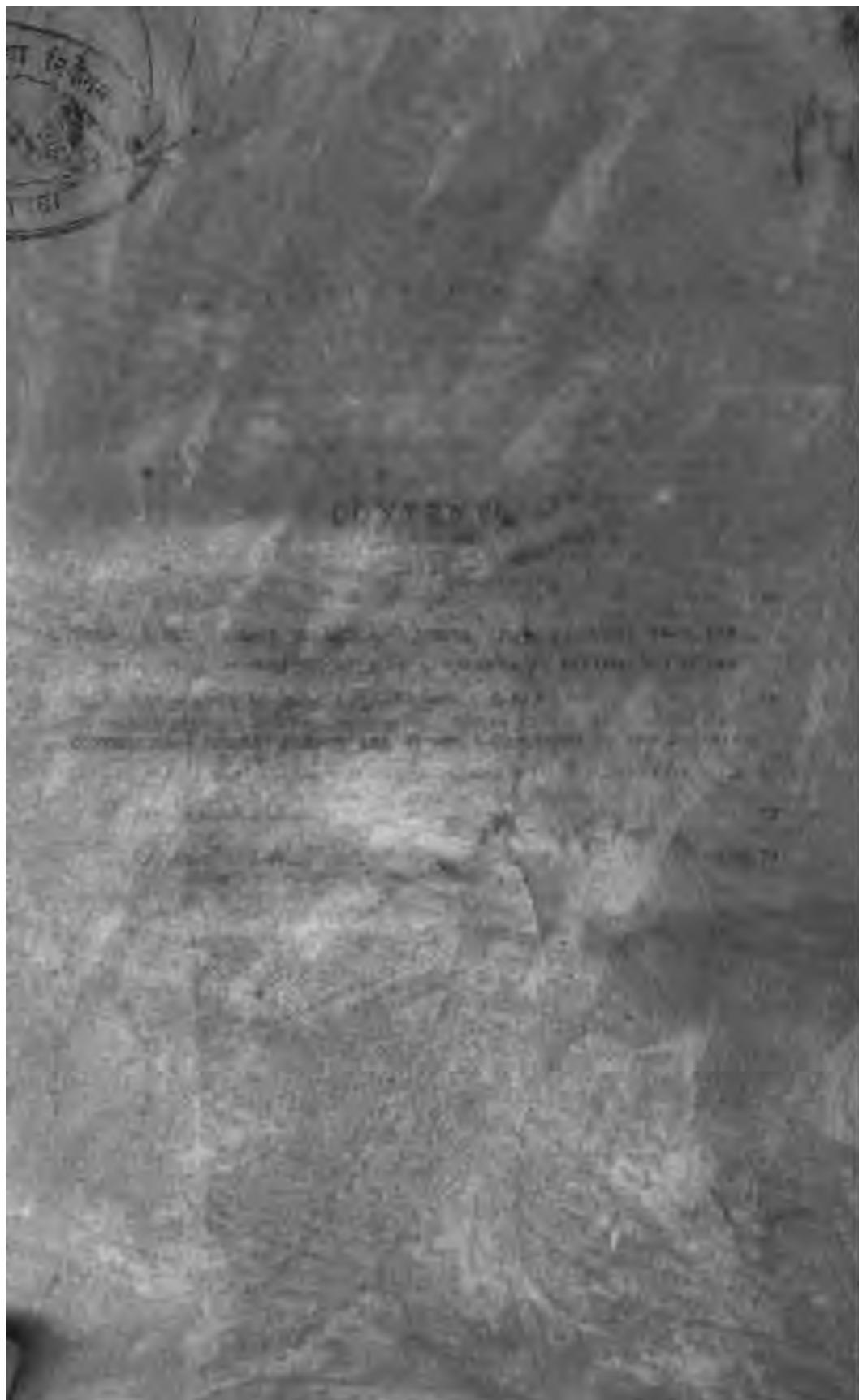
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1860.



RECORDS

OF THE

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Part 3.]

1869.

[August.

PRELIMINARY NOTES ON THE GEOLOGY OF KUTCH, WESTERN INDIA, resulting from the examination of that district, now in progress, by the Officers of the Geological Survey, by A. B. WINNE, F. G. S., &c.

The detailed examination of this province has been long looked forward to with interest, as promising to cast light upon the geology of other parts of India where fossil land plants similar to some of those occurring in Kutch have been found to characterize an extensive group of rocks and are almost the only fossils which those rocks contain.

These plants were known to be associated in Kutch with a large number of marine fossils, the Jurassic age of which was determinable, but the relations between the beds containing forms so distinct had still to be ascertained.

With this view a hasty visit was made to the district of Kutch by Mr. W. T. Blanford of the Geological Survey, in 1863, and the conclusions to which his observations led appeared in a short paper among the publications of the Survey. (Vol. VI, pt. 1.)

Except this comparatively recent paper other sources of information regarding the geology of the country, prior to the present investigations, were almost limited to a paper by Captain, since Major, Grant, read before the Geological Society of London in February, 1837; some remarks upon it by Dr. Carter in "Geological Papers on Western India" published by the Bombay Government in 1857; a record of some fossils by Colonel Sykes (Geological Society, London), and an interesting notice in Sir Chas. Lyell's "Principles of Geology," describing the effects of the earthquake of 1819, the elevation of the "Allah Bund," and submergence of Sindree village on the Runn, north of Lukput.

Of these Captain Grant's paper is the most detailed, but while it contains many valuable facts, several of these seem to have been affected to distortion by geological theories, or views, which have vanished since he wrote, and also by a misappreciation of the stratigraphic arrangement of the rocks. The four or five-fold sub-division adopted by him, being natural, is correct, though the sequence was mistaken.

THE ROCKS CLASSIFIED.

The following may indicate the ultimate arrangement of the larger rock-groups, some of the newer ones being perhaps capable of further sub-division:

RECENT AND SUB-RECENT	...	<table><tr><td>Blown sand.</td></tr><tr><td>Alluvium.</td></tr><tr><td>Concrete.</td></tr></table>	Blown sand.	Alluvium.	Concrete.	
Blown sand.						
Alluvium.						
Concrete.						
TERTIARY	...	<table><tr><td>Tertiary beds and</td></tr><tr><td>Nummulitic do.</td></tr><tr><td>Sub-tertiary.</td></tr></table>	Tertiary beds and	Nummulitic do.	Sub-tertiary.	
Tertiary beds and						
Nummulitic do.						
Sub-tertiary.						
JURASSIC	...	<table><tr><td>Stratified traps and Intertrappean.</td></tr><tr><td>Upper Jurassic (? Rajmahal.)</td></tr><tr><td>Lower Jurassic ("Dogger," or Middle Jurassic.)</td></tr><tr><td>Intrusive Traps.</td></tr></table>	Stratified traps and Intertrappean.	Upper Jurassic (? Rajmahal.)	Lower Jurassic ("Dogger," or Middle Jurassic.)	Intrusive Traps.
Stratified traps and Intertrappean.						
Upper Jurassic (? Rajmahal.)						
Lower Jurassic ("Dogger," or Middle Jurassic.)						
Intrusive Traps.						

[The syenite of Parkur-Nuggar, Kalinjur hill, &c., at the north-east corner of the Runn might be added to the above as the nearest base known for the Jurassic rocks.]

Of these the two Jurassic groups appear to have been transposed by Captain Grant under the names of "Older and Newer Secondary." The traps were looked upon as almost solely intrusive masses; their interstratification with aqueous beds being indicated at some places where association merely occurs, and at others where intrusion between stratified aqueous rocks takes place.

LOCALITY AND FEATURES.

The province of Kutch lies upon the west coast of Hindustan, about 400 miles north-west of Bombay, between the sea-ports of Kurrachee and Surat, or the provinces of Kattywar and Sind.

It is bordered on one side by the Arabian Sea and Gulf of Kutch, while upon all others it is isolated from the main land and the Thurr or little desert, by the grand and smaller Runns which are connected at the eastern side of the province. Its length from east to west is much greater than its breadth,* and, including the Runn, its area is estimated as being equal to about half that of Ireland.†

The whole province presents numerous alternations of hilly ground and open plains, sandy when covered by the detritus of the rapidly decomposing Jurassic rocks, and more earthy when underlaid by the Tertiary formation, both passing towards the southern coast, into broad alluvial plains of ordinary Indian aspect.

The hills are perhaps as often clusters as extended in the form of ranges, though these latter do occur; and more or less continuous escarpments rising with the outcrop of some of the stronger beds are very frequent. A broken chain passes nearly east and west through the Runn islands of Putchum, Khurree and Béla to Chorar, (in the former being flanked by a smaller range) :—another borders the Runn on the north side of Kutch Proper:—one, called the Charwar range, runs east and west to the southward of Bhooj, the capital of the province: and there are lesser ranges in other parts of the district, with many clusters and isolated hills frequently conical in form.

The hills of the Wagur or eastern side of the district, take no definite direction. They are the denuded remnants of what would have been a somewhat flattened and rolling dome shaped mass if their strata were continuous instead of having been extensively operated upon by denudation.

There are no lofty elevations in Kutch; that which is reputed to be the highest, namely, Dhenodur hill, overlooking the Runn on the western side of the province giving a measurement (by Aneroid) of but 1,070 feet above the Runn; several others, however, have elevations not greatly less.‡

Nearly all the ranges and many of the hills are steeply scarped on the north, and pass by gentle slopes into the plains to the south as a consequence of their structure, the beds in general having long southerly inclinations at low angles from three parallel lines of disturbance or dislocation which extend, 1st, from Putchum Isle to Chorar; 2nd, from Lukput, along the south edge of the Runn, to Doodye towards Wagur; and 3rd, from near Roha to the neighbourhood of Butchao, passing at the northern foot of the Charwar hills. North of these lines, and just in their vicinity, the beds are much contorted, their highest inclinations being always in a northerly direction.

The trap hills, particularly those formed of intrusive traps, are frequently surrounded by precipices, or else sharply peaked; an irregular range, however, formed of, or capped by, the bedded traps, running north-west from their broadest development in the Dora hills near the centre of the province out through its western half, follows the usual rule presenting long slopes upon the dip and steep ones along the outcrop of the beds.

The northern side of the province, generally speaking, has much diversity of form, being often picturesque, while, owing to the absence of jungle and prevalence of sand, its aspect is nevertheless barren; particularly when the view lies across a parched and glaring plain edged

* According to Captain Grant the extreme length is about 180 miles, and extreme width 50.

† 'Kutch Selections,' a collection of papers by various British Officials, published by the Bombay Government.

‡ Since writing the above, the height of a mountain in the Runn island of Putchum has been taken by Aneroid and found to exceed by some hundreds of feet any elevation measured in Kutch Proper. Dhenodur hill is not a volcano—see paper by Mr. Balfour, above mentioned.

by rugged hills, beyond a bright green patch with a few lonely palms, or other trees, near some village where wheat is laboriously cultivated with the aid of irrigation, and smoky clouds of sandy dust, raised by passing cattle, are driven before the northerly blast, from which those working at the wells shelter themselves by screens.

The peculiar bare, level and extensive plain called the Runn of Kutch is not a marsh, as represented upon some maps. It is periodically covered by water during the rains, and left dry, except a few patches, shortly after they have ceased; when those lower portions on which the water has lain the longest become strongly incrusted with salt,—this frequently extending as far as the eye can reach:—its dazzling surface flickering in the mirage, which magnifies or distorts any object that may happen to be upon the horizon. The source of the salt is probably from sea water, this being said to overflow the Runn, entering by the low ground at the mouth of the Koree river near Lukput, and also at the head of the Gulf of Kutch, when the sea on the coast is raised by the continued south-westerly monsoon winds.* However this may be, the waters from Kutch itself are strongly impregnated with salt derived from the rocks, great quantities of which in solution must be carried out to the Runn whenever there is sufficient rain to fill the rivers.

Although the incrustation is not very thick, being generally from one to two and a half inches, the quantity occurring on the Runn is enormous, and the way in which fish, insects and such organic remains brought in by the sea or down from the land by the Bunass and other rivers are preserved by the salt is evidence of the strength of the solution, if that were wanting.

Notwithstanding that traces of marine denudation are slight and scarce along the southern shore of the Runn,—having been probably removed by subsequent atmospheric actions—its whole aspect strongly suggests its being a gradually raised sea-bottom; a broad and slightly elevated tract called the Bunnee, lying along its southern side between Putchum Isle and Kutch Proper, being very possibly a bank or bar formed by the rivers which flow from the higher land in that direction. Over this tract coarse grass, a heathery looking tufted plant and Bâbul trees are irregularly distributed.

Some of the results of the great earthquake by which this country was visited in 1819 are still to be seen in the fallen walls of several of the towns, in the "Allah Bund,"† a low elevation, thrown up by it, which is said to have permanently arrested the southward flow of the water of the Koree or eastern mouth of the Indus, and in the submerged village of Sindree on its left bank; part of the ruins of the fort only being visible above the mud, salt and water by which they are now surrounded, no other trace of the village remaining, and the basements of the building seen being buried in the silt.

Tradition has it that this was formerly the site of a large city surrounded by villages and fields, and to which the tidal ebb and flow reached: subsequently (from elevation of the land probably) the river became so shoal that boats could not reach the port; the city was in a great measure abandoned, and another Sindree built several miles further down the river at a place called Sindu on the map. Here the same thing recurred, and Sindu was deserted, a new city rising at Lukput, once an important place, but now consisting of a few houses in one end of the walled in enclosure. At present boats cannot come even so far as this, and Lukput Bunder is at a distance of three or four miles, while the sea trade is conducted at Kotaisir close to the old mouth of the Koree river. How far the first part of this statement may be true is involved in considerable uncertainty, but it is said there are records in the *Dastier* at Bhooj which would prove the accuracy of some portions of it at all events.

JURASSIC ROCKS.

The Jurassic rocks occupy a large portion of the northern half of the province extending through it almost from end to end, and also forming the hilly parts of the Runn islands before mentioned. The bold scarps and rugged hills exhibit numerous fine sections, showing plainly the structure of the country through which, notwithstanding repeated rolling undulations of the beds and some very marked anticlinal flexures, many recurring southerly and

* It does not appear to what extent this has been proved, though from the aspect of part of the coast, it seems likely to be the case.

† Mount of God.

south-westerly dips place the lowest beds along the north side of the district, except where a great fault coinciding with the northern foot of the Charwar range causes them to re-appear in its centre.

These lower Jurassic beds consist mainly of gray, blue, red and black shales, thick and thin light-coloured sandstones and hard siliceous flags, with some more calcareous varieties, and in some places quantities of dun-colored and gray compact earthy or sandy limestone. Pale-purple sandstones and some highly ferruginous bands also occur, the whole presenting so many varieties of color and kind that its general lithological aspect is seen to differ from that of the uppermost Jurassic rocks, sufficiently to warrant an attempt at sub-division, only by regarding the group as a mass and leaving details aside. The passage from the lower beds to the upper is so gradual that no very definite boundary can be assigned between them. Still there is a difference at the extreme ends of the series which would at once prevent their being mistaken for each other, and which, it is supposed, led to their separation into two groups by Captain Grant.

Owing to the numerous faults, undulations and the general lowness of their dip, the thickness of this great series of Jurassic rocks is difficult to determine with accuracy, but it has been assumed, from observations in the part of the district lying eastward of Bhooj, to reach from 4,000 to 5,000 feet, of which measured sections of over 2,000 feet have been made in the lower portion of the group; and there is no reason to suppose its aggregate thickness to be less in the western side of the province. Throughout this large accumulation of strata there is a marked absence of regular zones, indicating successive stages of deposition, and while in such an assemblage of coarse sandstones and muddy shales with frequent conglomeritic beds much constancy of lateral extension might not be looked for, and marks of succeeding zones be probably obscure or absent, no want of material seems to have existed to supply new or similar layers for those which may have died out. The whole formation, particularly in its upper beds, maintains the same characteristics of obliquely laminated strata alternating with finer and more parallel deposits, all of richly varying tints, from black to white, blue, red, orange, brown and gray, and sometimes green with a peculiar golden oolite among the lower rocks which glistens like avanturine.

The lower beds on weathering take frequently a rusty color, and dull olive tints are common, while, where the beds are highly calcareous, a whole mountain formed of them with rounded outlines and a whitish hue in sunshine looks cool, and in cloudy weather as gray as any granite hill. Thick bands of a warm orange sandy limestone with some red beds occur also in the lower rocks, and many of their shales are gypseous.

The upper beds are marked by a predominance of clean white gravelly sandstone with some blackish ferruginous bands and white or lavender-gray, sometimes highly carbonaceous, shale. Between these and the lower beds alternations of almost every variety of rock in the formation occur, ranging through a vertical space equalling a third of the total thickness if not more. Many of the beds in both groups are strongly saline.

The lowest beds are much the most fossiliferous, and the remains are chiefly marine, including *Ammonites*, *Pleurotomaria*, *Ostrea*, *Trigonia*, *Cucullaea*, *Corbula*, *Gryphaea*, *Modiola*, *Terebratula*, and numbers of other bivalves, *Echinida*, *Crinoids*, *Corals*, *Belemnites*, fish teeth, reptilian bones, and fossil wood.

In one certain and one or two doubtful instances some of the upper beds of this lower and marine series were found to contain impressions of (terrestrial) *Zamia* in shaly bands interposed between the marine shell-bearing beds. During the examination of Eastern Kutch, the most exhaustive search that could be made failed to find any thing among the upper rocks except these *Zamia* and a few other terrestrial plants, but in the west, in a few cases, some marine fossils have been obtained from single beds occurring amongst unfossiliferous strata of the upper portion of the rocks, but still below the uppermost (white) beds seen.

This alternation or intercalation of the marine and freshwater beds (presuming those containing *Zamia* to be of purely freshwater deposition) being one of the points to which attention was specially directed, it is satisfactory to have so far ascertained the fact after many months of close search, even though such alternation appears to be much more limited than was supposed, unless it is taken for granted that the numerous fragmentary grass-like plant remains so common in the shales and flaggy sandstones throughout the formation are of freshwater deposition also. Many of these have been searched over and over again

without a trace of a *Zamia* leaf being found, and there seems to be no more reason for supposing them freshwater than some other beds in which ammonites occur lying among a mass of vegetable remains, the woody fibre of which is generally distinguishable, though often obliterated by carbonisation.

Such intimate association of the *Zamia* with marine forms has not, it is true, been discovered, but nevertheless it may not be unreasonable to suppose that these plants were floated out from land, and deposited by the sea at depths unsuited to the marine life of the period or at localities where this was from other causes absent. As Mr. Blanford has observed in the paper above mentioned, 'no sudden change in the rocks nor any unconformity has been found to mark the transition from a salt to a freshwater period'; and while it is evident that land plants may be carried out to sea, though marine organisms cannot so readily find their way into freshwater deposits, it is easier to believe that the whole of these salt Jurassic rocks are of marine origin than that repeated alternation of fresh and salt water beds takes place without any marked difference of character or aspect occurring in the rocks.

It may also be observed that though there are but few evidently marine beds, and these not immediately associated with *Zamia*-bearing rocks in the *upper* part of the Jurassics seen, still these *Zamia* beds contain plants only, no freshwater shells, fish, nor animal remains occurring to contest the possibility of the containing rocks being of marine or perhaps estuarine formation.

Great as is the thickness of the Jurassic beds, it is that only of a portion of the group the base of which is not visible, and the upper beds being unconformably overlapped by the Bedded Trap, they may continue to increase in quantity beneath the latter much further than they can be observed. There are, however, some appearances, along their uppermost boundary, which may be slight indications that the Jurassic period was drawing to a close, and that the deposition of rocks much resembling some of their upper beds ushered in the commencement of the succeeding unconformable tertiary group in those places at least where this succession was not interrupted by the accumulation of the intervening Bedded Trap.

TRAPS.

By far the largest part of the trap rocks is referrible beyond a doubt to the same period as the vast stratified accumulation known as the Deccan Traps. Some of the lowest flows are very thick, presenting few or no traces of bedding for more than 100 feet, but further up this is as plain as all the other appearances, such as beds of red boulders, alternations of amygdaloidal and columnar basaltic flows, presence of zeolites, and so forth, which characterise the formation elsewhere. The trap is sometimes magnetic, and among its lower beds ashy sandstone or calcareous bands occasionally exist. In one place near its local base an interstratified bed of friable red sandstone 30 feet in thickness was observed, and in another a small lenticular deposit of intertrappean calcareous rock containing small fish scales.*

The flows or beds have a low steady southerly or south-westerly inclination, forming a wide hilly belt through the centre of more than the western half of the province, but their deposition does not seem to have extended to the place occupied by the eastern extremity of the district. The thickness of this formation is much less than usual, being estimated at about 2,500 feet.

An obscure group of earthy sandstones formed largely of trappaceous materials, often indistinctly bedded and containing woody plant impressions, occurs in several places, having but indefinite relations to the lower part of the Bedded Traps, but resting quite unconformably on the Jurassic rocks and often closely associated with masses of intrusive trap near which also white sandstone is often strongly columnar.

The intrusive traps—occur chiefly in the Jurassic area, and probably mark some of the places from which those just mentioned issued.

They consist generally of angitic or basaltic traps varying in color (different black and grayish hues), and in texture from a close compact rock to one coarsely crystalline, the crystals of glassy felspar being interlaced, and the deeply weathered soft light-colored surface taking

* Within the last few days information has been obtained of the discovery by Mr. Fodderon of intertrappean beds containing *Phycis Priapus*, in the western extension of the trappaceous formation, furnishing still further proof of the identity of these with the Deccan Traps.

much the appearance of a syenite in similar condition. Fine muddy-looking or ashy trap, weathering to an olive-green minutely divided detritus, is another variety. Some of the dykes, &c., are of fine-grained purple colored trap, with white stearitic specks, a soft earthy or lava-like texture, are much less dense than the varieties abovementioned, and are sometimes salt to the taste.

With regard to the manner in which all these intrusive traps occur, nothing could well be more varied: dykes are particularly numerous in some localities; they also occur in faults, while local intrusions form hills projecting from the plains and Jurassic broken ground, like knots in decaying wood. In such cases, their outlines are either conical or combinations of this with steeply scarped forms. Some intrusions range through the country for many miles, presenting the most irregular lines both in plan and elevation, cutting across the aqueous strata, including large masses, intruded between them or forming hills either capped or underlaid by the Jurassic beds, or both one and the other, these being altered by the contact into various kinds of porcelainous or quartzitic rock, while one case occurs where a whole stream section of the aqueous rocks seems to pass by gradual intensity of alteration into solid trap in which planes resembling the original bedding can be traced for some distance as if the strata had been melted *in situ*, no marked difference of texture however existing in the trap, although the stratified rocks consist of alternations of calcareous sandy and thin shaly bands.*

Other instances occur in which sandstone seems to have been completely melted and taken up by these traps; the matrix having yielded first and the quartz fragments and grains gradually becoming more separated and disappearing until they are quite lost at a very short distance in the dark trap. This can be seen in hand specimens.

Generally speaking, these large intrusions have an intricacy of arrangement forming a tangle which defies all effort at accurate representation upon a map of small scale, and sometimes their basaltic trap is so magnetic as to deprive compass bearings taken from these points of any value, the variation being of inconstant amount.

SUB-TERTIARY GROUP.†

As already stated, the Jurassics or Dogger beds of Kutch, consisting of a calcareous or sandy and shaly marine series below, passes upwards into alternations of more ferruginous and more purely argillaceous and arenaceous beds,—in which land fossils (Zamia, Ferns, &c.) are either rare or locally numerous,—these forming what are at present considered an upper member of the same group. At some period subsequent to the Jurassic, not clearly marked, but arguing from local as well as distant sources of information (in the Deccan and at Bombay), probably an early Tertiary one, the volcanic activity which produced the Bedded Traps came into operation. Observations here only show that traps were extensively intruded through the Jurassic rocks, and that other traps, very probably connected with these as centres of eruption, constitute a thick series resting with marked unconformity upon these Jurassic strata.

But overlying the Bedded Traps and, where these are absent, the rocks upon which they rest, is a marked band of most peculiar aspect, having, in contact with these traps, a very volcanic appearance, but one entirely different from theirs. Its predominant colors are deep red and pure white, but it is finely variegated with purple, orange, greenish, brown and black or blue tints, even brighter and more strongly contrasted than those of the Jurassic beds. Its lowest stratum in junction with the uppermost of the trappian flows is a curiously mixed and mottled one, brecciated, concretionary on a large scale, in places containing small white quartz grains, but generally consisting of a pure chalk-white or variegated purple and lavender, unctuous, argillaceous, rock occasionally saline and speckled with white kaolin patches, giving it the appearance of an amygdaloid, sometimes to such a degree that it becomes undistinguishable from the purple trap found in several dykes among the Jurassic rocks.

* This passage as it were of stratified into intrusive amorphous rock is so very peculiar that it may perhaps be deceptive. A place where the alteration of the beds ceased laterally and the trap might be said to commence was sought for in vain, and the lines which may be, or at least simulate, original stratification apparently continuous with those of the unaltered bedded rock cease to be traceable beyond a few yards into the trap.

† The name Sub-Tertiary used here is only provisional. An examination of the fossils will probably cause it to be altered for another. It merely means that the beds are below the highly fossiliferous Nummulitic and other Tertiary beds though above the Bedded Traps the Intertrappian beds of which are believed to be of Lower Tertiary age.

Along the line of junction with the underlying Bedded Traps their uppermost layer is very commonly a greenish amygdaloid, also more or less generally concretionary, rusty or decomposed looking; instances occurring in which the concretions of the mottled rock have been found to exhibit an apparent passage towards their centres from one variety to the other, the cores being formed of rusty amygdaloid quite similar to that beneath. In other cases the lowest stratum of the mottled series or uppermost one of the trap is a pale greenish earthy trappian looking rock, not quite so concretionary as usual, with much of the external character of the mottled breccia, but containing yellowish green steatitic amygdala. Where these sub-tertiary beds rest on the Jurassic rocks the peculiar brecciated white bed is seldom strongly developed, but still is frequently present.

This breccia passes upwards within greater or less distance, as the bed is thick or thin, into gnarled and ponderous laterite of various red, black, brown and purple tints, either brecciated or of the brick-like character so well known elsewhere.* Its junction with the white rock below often shows rough stalactitic looking masses of the laterite vertically penetrating the lower bed all along the line of contact as if infiltrated from above. In the same group are other bands of laterite and some very coarse obliquely laminated white quartzose and ferruginous sandstone containing much of the white earth distinguishing the lower layer. Associated with these, but not always upon the same horizon exactly, are dull purple, brown and black, in some places highly carbonaceous, gypseous or pyritous shales containing numerous impressions of large and small *exogenous* and *endogenous* leaves. These occur also in fine flaggy pale lavender or white beds of the same group, but of uncertain place.

Apparently among gypseous reddish shales of this group a thin band was found to contain *Fasciolaria*, *Arca*, *Nucula*, *Cyprina* and *Venus*, which are not, however, in such a state of preservation as to warrant more than an opinion at present that they may be of either cretaceous or eocene age, while some bones of large reptiles, including part of a skull, have been found in very similar shales and on what seems to be very nearly the same horizon.

Close above these some brown flaggy sandstones containing a few shark's teeth and shells and occasional beds of earthy orange mudstone begin to appear, and indicate the approach to others abounding in tertiary fossils.

The thickness of this group (the 'Red—? New Red-sandstone' of Grant) varies much, from a mere band consisting of a few beds or only one, to a maximum, in some places, of between two and three hundred feet. Until the fossils have been examined, it is obviously difficult to say how much of this group may be of Tertiary age, if indeed it be not entirely so. It forms a marked basement to that series however, and where it rests upon the Jurassics without the intervening trap, its junction very commonly appears quite conformable, the line, however, being almost impossible to see when the gypseous shales of the one group overlie those of the other.

TERTIARY FORMATION.

As the Tertiary rocks are still undergoing examination, they can be but slightly noticed here, although they form a large and important feature in the geology of Kutch.

Their principal development takes place in the southern half of the western side of the district, where they form wide rolling plains under which the beds undulate, wrapping round the western termination of the Jurassic and Trap formations, and appearing at intervals along the southern shore of the Runn, on the margin of at least one of its islands, and at a few spots in the eastern portion of the province.

They consist, as a mass, of rubbly shales interstratified with yellow mudstone bands, and thick beds of sand or sandstone. Occasionally the rocks become sufficiently calcareous to be called limestone, and most of those containing fossils are highly so—an agglomeration of shell-casts in an earthy or sandy calcareous matrix.

Among the lower beds *oysters* and *turritella* are particularly numerous, whole beds being formed of the latter, and a flat echinus (*clypeaster*), being very common.

* At some localities in Eastern Kutch the laterite is associated with quantities of Agates both *in situ* and left in a thick layer by its weathering down, strongly recalling the appearance of some very similar ground similarly situated near the base of the tertiary rocks in Guzerat.

At a short distance above the base of the formation, on an average not more and often greatly less than 200 feet vertically, are soft and harder white calcareous beds crowded with *nummulites* and *fasciolites*, the former of several kinds, and associated with them are numerous *echini*, bivalves, &c.

The Nummulitic beds are generally nearly horizontal; they produce ground of singularly barren aspect, reminding one of the Egyptian desert, the white nummulites weathered out lying thickly upon the surface in place of soil, and from their abounding in that neighbourhood being called by the native Lukput paisa.

For several miles eastward of Lukput, along the edge of the Rann, these rocks are brought against the Jurassics by a fault, and having followed the low ground round the western limits of Kutch they disappear for a considerable space in the country north and north by east of Jackow, but set in again in the low lands further east.

In other parts of the low country, unoccupied by the Nummulitic group, highly fossiliferous tertiary rocks abound, containing a large number and great variety of genera, including *turritella*, *ostrea*, *conus*, *fusus*, *voluta*, *strombus*, *natica*, *trochus*, *oliva*, *cassis*, *cerithium*, *scalarium*, *cyprea*, *balanus*, *pecten*; *clypeaster*, *cidaris*, &c.:—of crustacea, some well preserved crabs, besides large bones and great molar teeth, and very many other interesting fossils, complete lists of which it is hoped will hereafter appear.

The thickness of these rocks is not yet sufficiently clear to be stated, but is considerable, probably exceeding 500 or from that to 800 feet.

It seems most likely that these Tertiary beds have been deposited in shallow water under shore conditions and subject to causes producing great irregularity of deposition. The occurrence of leaf beds in the group repeats the case of the Jurassic beds with regard to the alternation of fresh and salt water periods, and among the upper beds the predominance of sands almost devoid of organic remains indicates a different state of things from that under which the highly fossiliferous strata accumulated.

POST-TERTIARY.

In several places a coarse concrete is found containing numerous fossil oysters, generally of large size. It appears to rest unconformably upon the Tertiary rocks, and may be an old member of the coast series or "littoral concrete" of Western India.

Other post-tertiary and superficial deposits, such as alluvium, blown sand, river concrete, and a rock much resembling the latter, found high upon the banks of many of the hills, have merely to be mentioned, their occurrence here being in all respects similar to that in other localities.

Coal is often mentioned as occurring in Kutch. Carbonaceous shales have been met with in several places both in the Jurassic and Tertiary rocks, but chiefly in the former, and these sometimes contain layers of bright coal. This is usually very thin, forming but small parts of the bands quite too limited in thickness and extent (so far as known) to repay the cost of working.

The largest layer, opened upon formerly at the village of Trombow, north-north-east of Bhooj, is now concealed by the workings having fallen in.

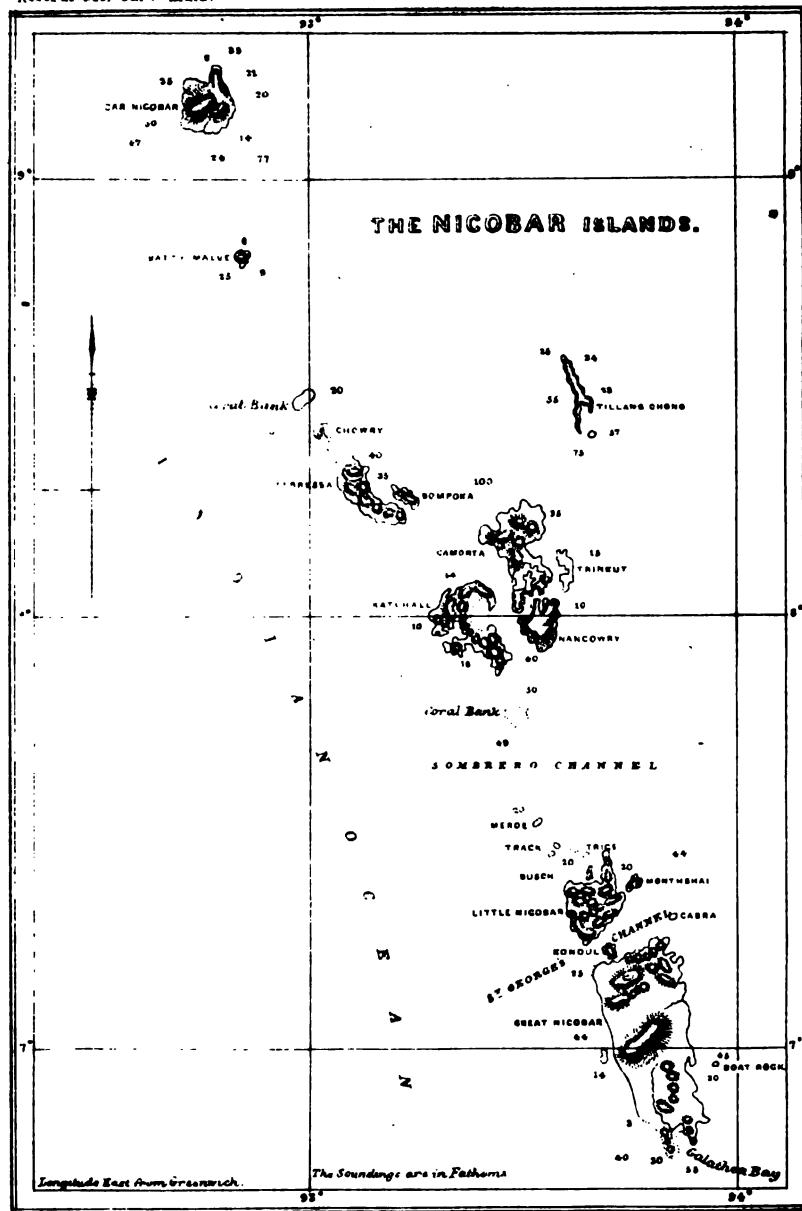
Alum is extracted in considerable quantities from the sub-tertiary shales of Western Kutch.

Iron used to be made in various parts of the province, but the manufacture has ceased in consequence of the facility with which Foreign iron can be obtained.

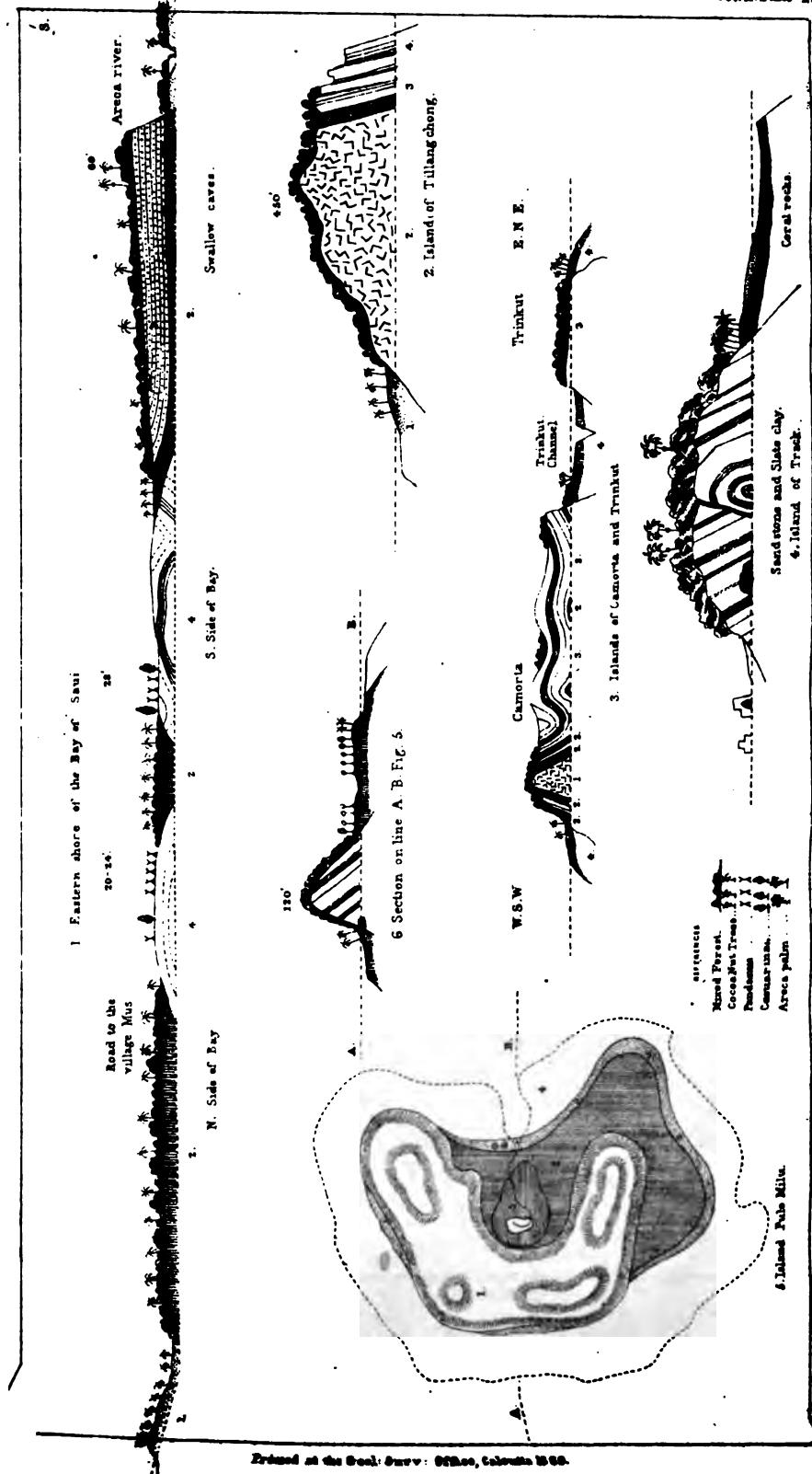
In conclusion, it remains only to be stated that several points of interest necessarily passed over in this hasty sketch have been reserved for subsequent consideration in the report to accompany the map, data for which are still being collected.

Amongst these are some facts tending to afford further proof of the association of aqueous deposits with the earliest beds of the Stratified Trap, and also indications that their highest flows or beds were not much older than the lowest Tertiary rocks, if indeed some of them were not contemporaneous.









The occurrence here of the persistent and well-marked band of laterite and its associated white clay or staeitic breccia, passing conformably upwards into the Tertiary beds, and less regularly, but still with an appearance of transition, into some of the bedded traps below, though differing from certain of the facts observed in the country north-east of Surat, may possibly modify some of the conclusions with regard to the more obscure occurrence of the same three groups, *i. e.*, the bedded traps, lateritic beds, and Tertiary rocks of Guzerat, or may, at least, confirm the impression of the volcanic activity which produced the bedded traps dating from early Tertiary times.

If, in the absence of fossils, lithological similarity be admitted as evidence, it may be possible that some of the white felspathic sandstones, considered as Upper Jurassic, overlying the *Zamia*-beds of Kutch, may represent some of the frequently similar looking *Mahadeva* or *Bâgh* beds of Central India and the Nerbudda Valley.

The evidence for a Jurassic age comes chiefly from the lower part of the series, which is certainly marine so far, and the occurrence therein of a band of shale containing *Zamia* may bear the explanation before suggested, but at present the discussion of these points is almost premature.

April, 1869.

Much interest having been excited in the history of the Nicobar Islands, which have recently been taken possession of in the name of Her Majesty the Queen of England, I have thought it desirable to print here a brief summary of all that is known regarding their geological structure. This could most effectively be done, by giving a translation of the reports of Dr. F. v. Hochstetter, who accompanied the Austrian 'Novara' expedition as geologist. Dr. Stoliczka, long a colleague and friend of Hochstetter's, has translated this report. The geological portion is given nearly at full. The part relating to the vegetation and its connection with the soils, however interesting to those who have never seen a tropical vegetation, contains little that would be new to residents in this country; and only a few extracts are given. A few remarks on springs and temperature conclude the paper.

The geology of the Nicobars has many points of the highest interest to the Indian geologist, as bearing on the structure of the adjoining Andamans, and the continuation of the same features into Burmah and northwards, on which connection some information will be given in future numbers.

T. O.

CONTRIBUTIONS TO THE GEOLOGY AND PHYSICAL GEOGRAPHY OF THE NICOBAR ISLANDS,
by DR. F. VON HOCHSTETTER, (translated by DR. F. STOLICZKA, from the "Voyage
of the Austrian Frigate Novara round the world in 1857-1859." Geological part,
2nd vol., pp. 83-112. Vienna, 1866).

The Nicobar islands (Pl. 3.) belong to an area of elevation which can be traced from the Bay of Bengal far into the southern seas. Beginning under the 18th degree north latitude in the group of the Cheduba and Reguain islands on the coast of Arracan, passing through the Andamans and Nicobars, then continuing through Java, Sumatra, and the south-western group of the Sunda islands, this line of elevation bends in an oblique S-form through New Guinea, to the north of the Australian continent, and forms in New Ireland, the Solomon Islands, New Hebrides and New Zealand a curve, concave towards the west, the small group of the Macquarie islands being possibly considered as the extreme southern end of this curve. Winding from the northern into the southern hemisphere through 70 degrees of latitude, this line, or area, is characterized as one of elevation by two phenomena, totally different in their nature, but nevertheless equally grand, and in certain respects related to each other. These phenomena are, first, the activity of the interior of the earth, showing itself in the volcanic action; and secondly, the activity of the coralline animals, disclosing itself in the formation of that kind of coral reefs which Darwin has distinguished from the barrier or lagoon reefs under the name of fringing or coast reefs.

Both phenomena, the volcanic action with its elevatory power, and the formation of coast reefs, are, in certain respects, related to each other, as has been placed beyond a doubt by Darwin's observations, although both do not appear together along all parts of this area.

In the southern extra-tropical latitudes, where coralline life does not exist on that large scale, the volcanic action is the only marked one, and equally so in tropical latitudes to the north of the equator.—where that action is locally wanting,—the peculiar formation of coral reefs must be considered as the principal argument for the continuation of this line of elevation. This is the case at the Nicobar islands.

These islands occupy a gap without volcanoes, between the volcanic range of Sumatra, and the Barren and Narcondam islands, which lie to the east of the Andamans.

Whatever may be hidden in the interior of the Nicobar islands, covered with perfectly impenetrable primeval forests and grassy plains, the occurrence of younger volcanic rocks is the least probable. Although I have found on the north side of Car-Nicobar, the northernmost of the islands, two pieces of a porous basaltic rock, the size of a man's hand, in a coarse gravel in the forest near the village Mus, and a larger angular fragment in the coral sand on the strand near the village Saui, still there is more reason to believe that these fragments were transported to the coast of Car-Nicobar in the roots of stranded trees,* or even that they were remains from the travelling bags of the Danish naturalists of the Corvette *Galathea*,—who in 1846, shortly before they landed on Car-Nicobar, visited the volcanic Barren island,—than that they came from the interior of the island. I have in vain searched for similar pieces in the stream- and river-gravels of Car-Nicobar, and I have not met with them on any of the other islands on which we landed.

On the other hand, the Nicobar islands are distinctly characterized as a portion of the chain of oceanic elevations, which began in former geological periods and still continues, by the upheaved coral banks and by the continuous formation of coral reefs, which slowly, but in the course of hundreds and thousands of years perceptibly, enlarge the territory of the islands.

The Austral-Asiatic area of elevation, above indicated in its entire extent, has in the Nicobars a mean direction to north-20°-west or from south-south-east to north-north-west, possessing a length of 148 Engl. (=37 Ger. geogr.) miles, and a width of 16 Engl. (=4 geogr.) miles. This direction indicates at the same time the strike of the strata on all the islands, while the dip is either towards east or west. The synclinals and anticlinals in the geological structure of the islands are thus coincident with the direction of the great geological line of elevation which connects the northern point of Sumatra with the group of the Andaman islands.

The total area of all the islands is calculated to be 33 to 34 German (geogr.) square miles (equal to about 528—544 Engl.).

1.—Geological Formations.

To render properly intelligible the results which will be given in the following pages, I may be permitted to make a few preliminary remarks.

It is at present extremely difficult to make any detailed geological observations on the Nicobar islands. One is limited to the sea coast, as impenetrable forests and grassy plains make the interior of the islands perfectly inaccessible and hide the rocks. On the northern smaller island, this circumstance is of less importance, because the extent of the rocks through the whole island can easily be ascertained, as soon as it is possible to observe them on two opposite sides of the coast in the same stratigraphical relation. The case is different with the southern larger islands. Sambelong or Great Nicobar has an area of 17½ geographical square miles, and is larger than all the other islands put together; it offers in the mountain ranges (rising up to 2,000 feet), and deep valleys, such a variety in the configuration of the ground, that it is impossible to suppose that what is to be seen on one or the other point at the coast should be characteristic for the whole island. The mouths of rivers being generally occupied by mangrove swamps, it is even impossible to come to any conclusions from gravels as to the rock which is to be found in the interior. But even on the coast there are great obstacles to geological investigation. Wherever the inquiring eye of the geologist observes promising cliffs, there breakers make it generally impossible to land, and where landing can be effected, we usually meet only a flat coast.

* Chamisso mentions the transport of stones in the roots of stranded trees on the Radak group, and Darwin gives a similar example from the Kieling islands. (Darwin's natural history travels, part II, p. 242.)

Thus one is limited in his observations to the few points, where during low water it becomes practicable to reach from the sandy shore some rocky promontory; and even under the best circumstances I was always restricted to that part of the coast on which the frigate anchored, for no amount of promises and offers could induce the natives to undertake longer trips with their canoes, neither was it possible to obtain a boat from the frigate at my disposal. I hope that other geologists, who may in future visit these islands, will be more successful in this respect.

My observations were therefore confined to the following places:—

1. *North-western coast of Car-Nicobar*.—A low precipitous coast accessible along its entire extent. Thick clay beds, with some more solid strata of sandstone, containing *Fucoids*, are on this coast overlaid by upheaved coral banks (coral conglomerate and coral sandstone); these are in some places still in direct communication with living coast reefs.
2. *Southern Bay of Car-Nicobar*.—Flat coral ground with fringing reefs, and at the breakers banks of a recent sandstone.
3. *Novara Bay on the west coast of Tillangchong*.—Precipitously rising cliffs of serpentine and gabbro conglomerate; at the breakers' coast reefs.
4. *Channel between Camorta and Nancowry, or the Nancowry Haven*.—A deep transverse cleft through yellow clay-marls containing magnesia, alternating with beds of serpentine and gabbro traps, and pierced through by serpentine and gabbro. A long stretching coral reef formation exists in the channel, but coral ground is very limited.
5. The small islands *Trice* and *Track*, north of *Little Nicobar*; precipitously upheaved; clayey sandstone beds with imbedded pieces of bituminous brown coal; coral and conglomerate banks and fringing reefs.
6. *Palo Milu*.—A small island on the north side of Little Nicobar, consisting of strongly raised sandstone beds, with flat coral ground, fresh water alluvium, and fringing reefs round the whole island.
7. Island *Kondul* on the north side of *Great Nicobar*.—Sandstone, sandy slates, and beds of clay-marl alternating with each other, flat coral ground of very limited extent, fresh water alluvium, and fringing reefs.
8. *A small bay on the northern coast of Great Nicobar*.—Sandstone hills, salt-and brackish-water swamps.
9. *East side of the southern bay (Galathea Bay) of Great Nicobar*, in which flows the Galathea river; sandstone mountains; flat coral ground, coral and conglomerate formation at the level of the breakers, fringing reefs; pebbles of bituminous coal on the strand.

These places are, with the exception of Car-Nicobar, the same as were seen by the Danish geologist Dr. Rink, accompanying the expedition of the Danish Corvette *Galathea* in 1846, and were, beside many others in the Archipelago, visited by him during a stay of four months, described in a special work.*

As to scientific inquiry, I left the Nicobars quite unsatisfied in spite of the comparatively long time of one month which we spent in their waters; I know well how little my own observations increase the geological knowledge of the islands, for which we are indebted to Dr. Rink; for just the grandest objects, the islands *Terressa*, *Little* and *Great Nicobar* remained for me totally a *terra incognita*. But I am conscious to have done every thing that it was possible to do under the circumstances, and in this point of view the few observations I can offer must be criticised.

Car-Nicobar is a low island, the average height of which above the level of the sea amounts to about 45 feet; only two ridges, which may be from 180 to 200 feet high, rise in the interior above the forest covering nearly the whole island. The west, south, and east, coasts are flat and sandy, and the north-west and south-east monsoons accumulate upon them gradually higher and higher fragments of corals and shells, which pass over the fringing reefs surrounding the whole island. The south coast is in part swampy, only the northern or rather the north-western coast, forming the shore of the bay of *Sau*, is precipitous, allowing a view of the geological structure of the island; the section of this coast is given

* Die Nicobarischen Inseln, eine geographische Skizze, mit spezieller Berücksichtigung der Geognosie, Kopenhagen, 1847. (The Nicobar islands, a geographical sketch with special reference to geology).

in the sketch Pl. 4, Fig. 1.—*Eastern shore of the Bay of Saui.* 1, Loose coral and shell-sand: 2, Dead coral-banks: 3, Indurated rock-beds of dead corals and shell-sand: 4, Plastic-clay with bands of sandstone.—

The eastern shore of the bay gradually rises from north towards south up to a height of about 60 feet, and includes two small lateral bays in which massive banks of a gray clay crop out below upheaved coral banks which form the projecting corners of the cliff. It is very characteristic that the boundary of the calcareous and clay strata on the surface of the coast terrace is at the same time a sharp limit of vegetation, inasmuch as on the clayey ground the *cocoa-palm* is replaced by *Pandanus*, *Casuarina* and grass, forming locally quite extensive grassy plains. The clay deposits, without any distinct stratification, show a cubical cleavage. The prevailing color is light-gray, only single bands are darker colored, others are ferruginous, containing numerous clay-ironstone nodules. The clay is a little calcareous, effervescing with acids. In the southern lateral bay also appears between the clay beds a more solid stratum from two to three feet thick, and from its projecting part larger and smaller plates are broken off. On one of these plates I observed the impression of a large species of *Fucus* (*Chondrites Nikobarensis*, Hochst.) The strike of the strata is from south-south-east to north-north-west in both bays, the greatest thickness observable in the strata amounts to 20 or 30 feet. This clay deposit on the northern coast of Car-Nicobar is characterised as a marine formation by the numerous *Foraminifera* which it contains, but I did not succeed in finding any recognizable remains of *Mollusca*, except indistinct and badly preserved bivalves (*Pelecypoda*).*

Farther towards the south, the clay beds again sink under the level of the sea, and in their place again appear coral banks, the precipitous coast becoming constantly higher, but at the same time gradually more inaccessible. On this coast the sea has washed out deep hollows, and the coral-banks are overlaid by massive banks of a white rock consisting of shell and coral sand, and being rather soft on the weathered surface. On the Areca river, in the innermost corner of the bay of Saui, the plateau of about 60 feet rapidly terminates with a fault, and the southern shore of the bay only exhibits a flat sandy strand richly overgrown with cocoa trees, being at the same time thickly populated. Judging from a few lumps in the gravel which I found on the northern as well as on the southern side, I conclude that there is somewhere in the interior of the island a gray fine-grained sandstone with little flakes of white mica and also a compact limestone *in situ*. The natives use the sandstone from the gravels as grinding stones.

Batty Malve is a small rocky island with precipitous shores all round. It rises on the south-eastern and eastern side in two terraces to about 150 feet. On the western and north-western side, it runs into a low flat cliff; judging from a distance of two or three nautical miles—we did not come nearer—the island is inaccessible. The extreme shore seemed to be covered with grass only, the interior was a low jungle, the crown of cocoa-palm being here and there visible at its margin. Only opposite Car-Nicobar can the island give an impression of a "relatively bare rock," as Steen Bille† says.—The rocks to be found on the island are most probably the same as those of Car-Nicobar.

Tillanchong, situated opposite Car-Nicobar, is a narrow mountainous island with precipitous cliffs, stretching from north-west towards south-east; it consists of two rugged mountain ranges separated by a depression of only 30 feet in depth. Where, on the south-east side, both ranges meet, a deep bay is formed, which during the north-west monsoon offers an excellent place for anchorage. The less precipitous south-western coast is highly precipitous all along the shore. The highest hills are situated in the northern part of the island, apparently rising to an elevation of about 500 feet. Serpentine and gabbro form no doubt the great mass of the island.—Pl. 4, Fig. 2.—*South-east coast of Tillanchong.* 1, Coral-rocks; 2, Serpentine and Gabbro; 3, Breccia; 4, Sharply elevated rock-beds.—

In the small bay on the south-western coast, the Novara bay, in which the frigate was lying at anchor for a few hours, the irregular and cliffed-like shores are composed of common

* The description of the very well preserved *Foraminifera* from the above described clayey beds was undertaken by Dr. K. Schwager. His very valuable paper will be appended to this chapter of the Nicobar Islands, and for further results I here refer to this paper.

† Captain Steen Bille was Commander of the Danish ship *Galathea*.—T. O.

serpentine, often traversed with veins of hornstone, and the same is the case with the thickly wooded mountain slopes, as far as could be observed in the small rocky beds of streams. The shore exhibited a very great variety in the color of the serpentine, jasper and hornstone pebbles: besides these, however, there were noticed also numerous pebbles of a dark green diallage rock, which must no doubt be *in situ* somewhere on the same coast at no great distance.

From the angular fragments of serpentine and other masses in the course of decomposition, a ferruginous breccia is formed at the foot of the hills, while in the breakers the serpentine gravels are being cemented by coral and shelly sand forming solid sandstone and conglomerate banks which recall the Verde-antique, (Ophicalcite). The plateau of the coast-reefs extends 2 to 300 feet from the precipitous shore into the sea. The whole of the island was covered with thick primeval forest which thrives well, even on the serpentine ground.

In passing along there were observed on the southern part of the island and on the eastern coast thin-bedded rocks with a high dip; these were in massive cliffs almost perpendicular in the south-eastern bay with a columnar structure; their true nature remained, however, unknown to me, for I was unfortunately obliged to use the telescope in place of the geological hammer.

Camorta, Trinkut, Nancowry with *Katchall* form the middle group of the Nicobar islands. Trinkut is situated in front of the eastern entrance of a channel between Camorta and Nancowry; it is a low island surrounded by coral reefs, and on its southern coast whitish-yellow argillaceous marls crop out. *Camorta* and *Nancowry* exhibit a greater variety of formation.—Pl. 4, Fig. 3.—*Sections of Camorta and Trinkut.* 1. Gabbro and Serpentine; 2. Breccia and tufa; 3. Clay marl with sandy beds; 4. Coral-rocks.—The channel between the two islands, the Nancowry haven, has numerous small bays and corresponds with a transverse cleft, while the Trinkut channel is a longitudinal cleft. The precipitous shores of the former offer, therefore, the most instructive geological section.

The narrow western entrance to the Nancowry channel is marked by two projecting rocks, which have been washed out by the force of the waves, making thus a natural gateway of rocks. Both cliffs rising almost perpendicularly to about 80 feet, are formed of a coarse breccia, composed of angular fragments of serpentine and gabbro* firmly cemented. I could not observe any stratification in this rock on the Camorta side; it is here in cliffs with large quadrangular blocks. On the Nancowry side, however, coarser bands alternate with finer tufa-like ones, with a strike from south-south-east to north-north-west and dipping about 85 degrees towards west. On the Camorta side, there crop out at two places below heaps of masses of rocks, which Rink very properly regarded as friction-breccias, cliffs of a more or less serpentine or gabbro-like massive rock.

Among the pebbles on the strand, I also met with numerous fragments of a reddish-brown rock traversed by white calcite veins, the rock which Rink called Eurite.

These phenomena at the western entrance to the Nancowry-haven are thus perfectly identical with those which Rink has observed at the entrance of the Ulala bay, situated only a few miles to the north; they are represented (l. c. p. 68) by Rink in a section. Further to the north the mostly bare hills on the west coast of Camorta, recalling by their external shape conical volcanic forms, attain a height of from 4 to 500 feet; they no doubt indicate the further extension of the serpentine and gabbro-rocks, which on Camorta and Nancowry are traversed from south-south-east to north-north-west by a longitudinal cleft.

In the interior of the Nancowry haven, wherever the rocks are exposed on the projecting angles, they appear to be well-bedded, whitish-yellow, clayey marls, alternating with banks of a fine-grained sandstone, with serpentine and gabbro tufts.

Most instructive in this respect is the precipitous south-eastern corner of Camorta at which the coast line bends into the Trinkut channel. The argillaceous marl formation is here well exposed in cliffs of from 30 to 80 feet high. On the southern side of the corner the transverse section of the strata can be observed, dipping at 25° to 30° towards west, while on the eastern side, parallel to the longitudinal break, the beds crop out horizontally one above the other. The argillaceous marl does not contain fossils, is of a yellowish white color,

* Gabbro is a rock composed of diallage, smaragdite or hypersthene with labradorite or saussurite, and often some other minerals in an irregular mixture.

and on the perpendicular walls it was covered with inch-long, white, very thin, crystals of a silky lustre. The examination of these showed them to be sulphate of magnesia. The clay itself contains, according to Rink's analysis, besides silicate of alumina, iron-oxide and magnesia.

The whitish-yellow clay marls of Camorta and Nancowry being entirely free of lime have become famous since Professor Ehrenberg (Berl. Akad. Monatsberichte 1850, p. 476), by an examination of the samples brought by Dr. Rink, has shown that they are true *Polycistina*-marls, like those of the Barbados. Ehrenberg discovered in 1848 about 300 species, which were by Professor Forbes believed to belong to miocene (tertiary) deposits. Ehrenberg says: "Especially well developed is this material on Camorta, where, near Frederickshaven, a hill 300 feet high is covered all over with variegated *Polycistina*-clay, while the Mongkata hills on the eastern side of the island are according to Rink entirely composed of a whitish-clay resembling meerschaum; this is, according to my analysis, a nearly pure agglomerate of beautiful *Polycistina* and their fragments, beside numerous *Spongiolites*."* The species of *Polycistina* on the Nicobars are, according to Ehrenberg, the same which compose the similar marl on the Barbados, situated in nearly the same latitude; but there are also some new forms.

Near the level of the sea, the clay marls, which locally contain angular fragments of serpentine and gabbro, alternate with more solid strata of a psephitic rock, which is composed of strongly-cemented angular fragments of serpentine and gabbro, and can therefore be best designated as gabbro-tufa. It is remarkable that this rock again includes larger and smaller pieces of the clay marl. On the eastern coast, near the village Inaka (Enaca) a reddish micaceous sandstone appears between the clay marls.

Similar are the geological conditions on the northern coast of Nancowry. Between the villages Inúang and Malacca, the whitish-yellow clay marls crop out in slightly inclined strata; between Malacca and Injáong, however, lies a precipitous cliff, on which these strata rise almost perpendicular, and are gradually replaced by an accumulation of fragments of serpentine and gabbro. At the projecting corner itself, the traveller faces a precipitous cliff of about 60 feet in height, but being cracked and decomposed, the true nature of the rock is recognised with difficulty. On a fresh fracture, however, one soon observes a massive diallage rock, the laminar diallage being clearly traceable in the nearly solid mass of felspar. Narrow veins of quartz pass through the rock.

From here up to the village Injáong the strand is again flatter, and nowhere nearer than on the other side of the village high, dark-colored, rocks are a second time visible, indicating a massive rock. These are the two places which Rink also has marked on his maps as plutonic rocks.

Trice and Track.—On the north-western point of the small island Trice, highly upheaved banks of a fine-grained argillaceous sandstone of a greenish-grey color form a low precipitous shore. The same stratified rocks alternate with thin-bedded sandy slates, showing on the south-eastern coast margin of the small island Track, only a few cables length distant, the accompanying section. Pl. 4, Fig. 4. Besides a fault, the strata form a saddle and strike from south-south-east to north-north-west. In a sandstone bank I found here imbedded a rolled fragment of a bituminous coal, the same of which I met with a larger but equally-rolled fragment on the strand of the island Trice. Of coal seams there was, however, no trace to be detected; what might be mistaken for them from a distance was only the shadow of softer sandstone banks deeply weathered out, or the darker color of some strata.

Pulo Milu.—A small island on the northern coast of Little Nicobar, which Dr. Rink has so excellently described in all its peculiarities, consists, in the higher parts, of a grey, fine-grained, micaceous and calcareous sandstone in massive banks. Very often spheroidal concretions are to be observed showing on the soft weathered surface like cannon balls. No trace of fossils could be found. The massive banks have thin-bedded sandy slates interstratified. The strata strike from south-south-east to north-north-west, dipping to east at an angle of 45 degrees. Dr. Rink (loc. cit. p. 50) mentions a fossil resin in the sandstone of Milu.

* The result of examination of a Nancowry specimen is figured on Plate XXXVI of Ehrenberg's "Mikro-geologie."

Pulo Milu was particularly instructive for me, because the dependence of the vegetation on the soil and its geological basis could be perfectly well recognised. The vegetation and the geological formation of the ground stand in the closest relation to each other, as clearly shown by the accompanying sketch plan. The sandstone hills are covered with jungle; the coral (calcareous) ground with high forest trees; the saline, calcareous, sandy ground is occupied by cocoa-palms, and in the fresh water swamp on the declivity of the hill range, which resembles in its curve a horse shoe, thrives the finest forest of *Pandanus* which we have seen on the Nicobar Islands.—Pl. 4. Fig. 5. *Plan of the island of Pulo Milu.* 1, Sandstone with bushy forest; 2, Coral conglomerate, with high tree forest; 3, Coral and shell sand, with forest of coco-nut trees; 4, Coast reefs; 5, Fresh water alluvium, with forest of *Pandanus*. Pl. 4, Fig. 6, *Section of same island on line A. B. Fig. 5.*

We have not visited the coast of Little Nicobar, the mountains of which rise to 1,000 feet elevation above the sea.

Kondul—between Little and Great Nicobar,—consists of a hilly ridge, $1\frac{1}{2}$ nautical miles long and $\frac{1}{2}$ mile broad; its strata strike north-north-west., and dip at 70° towards east. The western side is the precipitous one. The strata represent an alternation of more or less sandy or clayey beds. The sandstone predominates, yellowish-white, with ferruginous reddish-brown particles. The clayey beds partly consist of a greasy plastic clay, partly of a crumbling yellowish clay marl, with intercalated thin-bedded sandy slates. The only organic remains which I found were indistinct traces of *Algae* and small rolled fragments of coal.

Great Nicobar.—What shall I report of Great Nicobar? With the exception of some sandstone hills on the northern coast, and the sandstone ranges on the eastern side of the Galathea Bay in the south, I have not seen anything. Great Nicobar, with its mountains rising up to 2,000 feet, is geologically quite a *terra incognita*.

A very remarkable earthquake, which is said to have lasted from the 31st of October to the 5th December, 1847, on the Nicobar Islands, at which time also earthquakes occurred in the middle and western part of Java, is described from the *Penong Gazette* in Junghuhn's *Java* (part II, p. 940). On this occasion fire is said to have been seen on one of the mountains of Great Nicobar.

Can the highest mountain of Great Nicobar be a volcano? Its form is that of a volcano, but as Junghuhn says that one could land on the southern coast of Java, wander about many days among sandstone and slate rocks, without obtaining through any of the phenomena even a trace of the stupendous volcanic nature of Java; in the same way there may be in the interior of Great Nicobar, rock-formation hidden, of which one does not get an idea along the coast. However, I do not attach any importance to the rumour that fire has been seen on Great Nicobar, though the description of the earthquake seems trustworthy, as I had myself occasion to observe on Kondul the mountain-slips referred to in the account.

These few observations, combined with those of Dr. Rink, give us the following, though probably still very imperfect, idea of the geological nature of the Nicobar Islands.

Among the various geological formations on the Nicobar Islands, three are the most important:—1, *An eruptive serpentine and gabbro formation*; 2, *Marine deposits, probably of a younger tertiary age, consisting of sandstone, slates, clay marls and plastic clay*; 3, *Recent coral reef formations*.

The serpentine and gabbro formation of the Nicobars is characteristically of an eruptive nature. The tertiary sandstones, slates and clay-marls appear forcibly broken through; their strata are partly inclined, partly bent in flat, parallel, wave-like, undulations. These rocks are accompanied by coarser and finer breccias composed of angular fragments of these same rocks, and they can partly be regarded as friction-breccias, partly as sedimentary tufas in which beds of an argillaceous marl are interstratified. The eruption of these plutonic masses appears, therefore, to fall in a time when the formation of the marine deposits was partially completed, partially still in progress. They broke through, on lines of fracture of which the principal strike from south-south-east to north-north-west agrees with the longitudinal extension of the islands. On the middle islands, the serpentine and gabbro attain their greatest development; on Tillangchong, Terressa, Bompoka, Camorta and Nancowry they form bare hill-ranges of from 2,500 feet elevation, and their configuration often marvellously

resembles those of younger volcanic formations. The elevatory power has, however, acted most strongly on the southern islands, and has here upheaved sandstones and slates probably to heights of 1,500 to 2,000 feet above the level of the sea; on the low northern islands the same power was, on the contrary, weakest.

With regard to the sedimentary deposits, I may state that Rink called the argillaceous deposits of the northern islands "older alluvium," and the sandstones and slates of the southern islands "brown-coal formation." In separating them from each other, he considers the former as being derived from plutonic rocks through chemical and mechanical decomposition, and as only of a local character. According to this the archipelago of the Nicobars is divided by him into two geologically different groups,—an opinion with which I cannot agree.

The clays and clay-marl formations of the northern islands, Car-Nicobar, Teressa, Bompoka, Camorta, Trinkut, Nancowry, and the sandstones and slates of the southern islands, Katchall, Little and Great Nicobar, appear to be only petrographically different products of one and the same period of deposition. There are at the same time very few materials from which the age of the marine formations could be determined, as the only fossil remains which have been found in their strata are fragments of *drift wood* changed to brown coal, plant impressions resembling *Fucoids*, *Foraminifera* and *Polycistinae*. But all these remains indicate more or less distinctly a young tertiary age.

The same conclusions are derived from a comparison with the geological conditions of those islands which lie on the same line of elevation as the Nicobars; I refer especially to Sumatra and Java.

I have not the least doubt that the clay-marl and sandstone formation has its perfect analogue among the tertiary deposits of Java, which I had myself the opportunity of studying and comparing in their distribution and lithological character. These became first known through the late Fr. Junghuhn, whose researches on the physical geography of Java are of such merit.

According to Junghuhn, one-fifth of the surface ground of Java is alluvial soil. This is especially prevalent on the northern side of the island, extending from the coast inwards either one, or sometimes five to ten English miles; one-fifth of the island consists of volcanic cones, and their immediate vicinity where the lower rocks are covered up by volcanic products. These conical hills chiefly occupy the interior of the island, sometimes in a double range stretching from west to east; while three-fifths of the area are occupied by tertiary rocks. Either in flat protuberances or in clod-like elevations, these tertiary rocks surround the volcanic range always on two sides, on the southern as well as on the northern. On the northern side, the less highly upheaved tertiary strata underlie the alluvium, and therefore occupy on the surface a small area. In an unequally greater degree, the tertiary deposits are developed on the southern side of the volcano, both as regards height and horizontal extent. They are mostly visible split in clods (schollen) which always rise higher towards one side,—the north, or towards the volcanoes,—and are at their highest edge upheaved to 2, 3 and even to 4 thousand feet. It is also principally on the southern side that plutonic rocks occur in the neptunian deposits of Java, which are occasionally only represented by narrow and sharply defined veins, without any influence upon the structure and configuration of the surface; sometimes, however, they form small hill ranges or isolated hills, similar to the serpentines and gabbros of the Nicobar islands.

According to the reports of the Dutch Mining Engineer, Huguenin,* a repetition of the geological formations of the Nicobars appears to be met with in the Tjiletuk Bay (the southern lateral bay of the Wynkoop Bay on the southern coast of Java). The prevalent formations here are sandstone-conglomerate and highly developed greenstone-breccias, besides plutonic rocks of the greenstone group. From specimens which I had an opportunity of seeing in the local collection at Beutenzorg, I found that these plutonic rocks are serpentines, gabbros and aphanites, exactly similar to those of the Nicobars. Equally identical appears to be the chalk-white clay-marl in the middle portion of Bantan, and the fine white marls in the southern portion of Tjidamar, mentioned by Junghuhn (loc. cit., p. 13), with those occurring on the Nicobar islands.

* *Naturkundige Tijdschrift voor Nederlandsch Indie*, Theil XII, p. 110, 1856.

At the time of my stay in Java (1858), and from all I could find described, as well as from my own observation, I came to the conclusion that in the tertiary deposits of Java two principal groups can be distinguished, setting aside the limestone formation, the proper place of which in the system of Javanese deposits is as yet doubtful.* 1. *A lower coal-bearing group*: numerous workable seams of brown coal are imbedded in quartzose non-calcareous sandstone and slate-clay with silicified stems of trees; marine shells are very rare, or absent. To this I referred the coal seams discovered by Junghuhn in the south-western part of Java, as also the coal formation on the Kapuas river in West Borneo, and the extensive coal districts in Southern and Eastern Borneo, finally the coal of Benkulen (Bencoolen) on Sumatra, and numerous other similar deposits scattered over the Indian Archipelago. 2. *An upper group without coal*: a clay and sandstone formation with plastic clay-slates, argillaceous marls, calcareous sandstone, trachytic tufas, breccias and conglomerates, rich in marine shells, fossil plants, fossil resin, but merely with nests of coal in place of coal seams.

Reasons, which I have given elsewhere,† have induced me to regard this complex group of strata as probably of Eocene age. This opinion may even now stand as regards the lower group, while as regards the upper group, I gladly accept the opinion of my friend Baron v. Richthofen, and the conclusions derived by H. M. Jenkins,‡ from which these fossiliferous deposits appear to be younger Miocene.

I suspect that to this upper Miocene group correspond the tertiary deposits of the Nicobars, although fossils confirming this suggestion have yet to be discovered. It is also beyond doubt that these deposits are not wanting on Sumatra, in certain respects a connecting link between Java and the Nicobars. Junghuhn (*loc. cit.*, p. 8) justly remarks: "The tertiary formation appears to have a sub-marine extent over the whole of the Indian Archipelago, because wherever within this Archipelago the earth's surface rises above the level of the sea, this neptunian formation is observable. I know this for certain as regards Northern Sumatra, where the tertiaries are especially found in the Batta districts (Batta ländern). With the exception of the trachytic island Dungus Nasi all the islands in the Bay of Tapannli (situated exactly in the prolongation of the Nicobars), besides the adjoining low shores of Sumatra, and partially also the mountains near Tuka, are composed of more or less upheaved sandstone strata, containing, though sometimes rarely, tertiary shells." Thus it appears to be principally on the southern coast of Java and the south-west coast of Sumatra that we find a repetition of the geological conditions of the Nicobars.

The commencement of the eruptive formation is in Java inaugurated by serpentine, gabbro, massive rocks resembling diorite (greenstone trachytes as in Hungary); more or less typical trachytic rocks follow, and the grand volcanic eruption extending up to the present time from the termination of the enormous eruptive phenomena in the Indian Archipelago. At the same time it appears that the eruptive line has been shifted slowly, on Java from south to north, and on Sumatra from south-west to north-east, so that this line would strike east as regards the Nicobar group in the same longitude in which east of the Andamans it reappears on the volcanic Barren Island and Narcondam.

The young tertiary age of the serpentine and gabbro eruptions on the Nicobars and Java has its perfect analogue in the eruptions of the same rocks in Central Italy, which, according to Signor Perazzi, in Turin, and Prof. Savi, are partly Eocene, partly Miocene, and which, on account of their copper ores, are of importance to the miner.

The third principal formation of the Nicobars are coral formations, belonging to the most recent or the present period. Coral banks of great thickness are found on Car-Nicobar, Bom-poka and several other islands; they consist partly of a compact coral limestone, partly of a coral or shell conglomerate, upheaved up to 30 and 40 feet above the present level of the sea; on all the islands, the original area is to be observed enlarged by coral-land, which is only separated by the higher sand dunes along the shore, from the still continuing formation of the coral reefs surrounding all the islands in the character of fringing reefs. Although these raised coral banks are a decided evidence, in favor of the long continued

* According to Junghuhn this limestone is the youngest of all the formations, and is always to be found only in superficial banks.

† Reports on the doings of the mining engineers in Netherlands India (*Jahrbuch der k. k. geol. Reichsanstalt*, Wien, 1858, p. 277).

‡ Quart. Jour. Geol. Soc., London, Feb., 1894.—F. Baron v. Richthofen, *Zeitschrift der deutschen geol. Gesellschaft*, Bd. 14, p. 327.

